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Ross Mould Inc.
Washington, Pennsylvania

NIOSH INVESTIGATORS:
John Kelly, M.S.
Pete Fatone, M.S.
Randy Tubbs, Ph.D.
Tom Van Gilder, M.D.

I. SUMMARY

At the request of the American Flint Glass Workers Union local 146, the National Institute for Occupational Safety and Health (NIOSH) conducted a health hazard evaluation at Ross Mould in Washington, Pennsylvania. The union's concern was for employees who reported numbness in their fingertips which they associated with the use of power hand tools during grinding, polishing, and deburring of machined molds.

NIOSH investigators made two visits to Ross Mould. On November 3, 1993, investigators interviewed employees and videotaped the work process. On March 22 & 23, 1994, NIOSH investigators measured employees' exposures to hand-arm vibration (HAV). Measurements were made on 21 tools used by nine employees.

The mean HAV exposure for the nine employees, expressed as 4-hour equivalent exposures, was 28 meters per second squared (m/s^2). Mean HAV exposures ranged from 18 m/s^2 to 40 m/s^2 for the three different job titles that were evaluated. These values are above the 1-hour threshold limit value (TLV) of 12 m/s^2 recommended by the American Conference of Governmental Industrial Hygienists.

The results of this investigation indicate that a potential health hazard exists at Ross Mould from overexposures to hand-arm vibration. Recommendations for addressing this potential hazard, including establishing a medical monitoring program, are provided in section VIII of this report.

KEYWORDS: SIC 3544 (special dies and tools, die sets, jigs and fixtures, and industrial molds), occupational vibration, hand-arm vibration, HAV, segmental vibration, vibration white finger, Raynaud's phenomenon, ergonomics.

II. INTRODUCTION

On January 7, 1993, the National Institute for Occupational Safety and Health (NIOSH) received a request from the American Flint Glass Workers Union (AFGW) local 146 to conduct a health hazard evaluation (HHE) at Ross Mould Incorporated in Washington, Pennsylvania. The union's concern was for employees who were reportedly experiencing numbness in their fingertips from the use of power hand tools. In response to the union's request, NIOSH investigators made two site visits to the plant.

During the first visit on November 3, 1993, the NIOSH medical officer conducted employee interviews and the industrial hygiene team surveyed the work area, videotaped the work process, and attempted to make preliminary measurements of employees' exposures to hand-arm vibration (HAV) during tool use. Eleven workers who used hand-held vibrating tools were interviewed for symptoms of hand-arm vibration syndrome (HAVS) or other upper extremity musculoskeletal disorders. In addition, information about work history (e.g., job description, length of time at job) and work practices (amount of time using tool, how long the tool was used, use of gloves) was obtained during the interview. An interim report, which summarized the activities and findings of the November survey, was sent to representatives of Ross Mould and AFGW local 146 on February 15, 1994. A copy of that letter is provided as Attachment 1 of this report. During the second visit on March 22 & 23, 1994, the NIOSH industrial hygiene team measured employees' exposures to HAV during the grinding, polishing, and deburring of machined molds.

III. BACKGROUND

Ross Mould Inc. manufactures molds which are sold to other companies who use them to produce glass containers. Castings, made of iron or bronze, are machined into molds which are ground, polished, and deburred using power hand tools. The NIOSH investigation was restricted to the grinding, polishing, and deburring operations. Except for one tool, an electric grinder made by ENGIS, the power hand tools used were pneumatically-powered tools manufactured by Cooper Industries and marketed under the name DOTCO. Some of the tools used were newer models which Cooper advertises as ergonomically designed tools. Among the modifications to these tools, was a material on the handle which is supposed to damp the vibration transmitted to the worker.

Production at Ross Mould runs 24 hours per day, Monday through Friday. The employee population that used the power hand tools in March consisted of 53 males, ranging in age from early 20's to late 50's. The majority of these employees were scheduled on the day shift from 8:00 a.m. to 4:00 p.m.; however, most employees reported that they worked up to 10 or 12 hours per day. Employees are provided with two 5-minute breaks and one 15-minute lunch break during their shift.

IV. EVALUATION CRITERIA

A. Hand-Arm Vibration (HAV)

Occupational exposures to vibration can impact upon the whole body, as is the case for truck drivers and earth-moving equipment operators, or exposures may be restricted to the hands and arms, which is the case at Ross Mould. Hand-arm vibration (HAV), also called segmental vibration, refers to exposures of the hands or arms to mechanical oscillation. Oscillation refers to back and forth movement like that of a pendulum. Power hand tools also oscillate. However, unlike a pendulum which swings back and forth along two axes at a single frequency, power hand tools oscillate along three axes over a range of frequencies. The distribution of these frequencies is referred to as the frequency spectrum of the tool. The oscillating movement is a vector quantity, having both amplitude and direction. Therefore, both the amplitude and direction of the oscillation must be measured when evaluating exposures to HAV. In summary, the health effects of HAV exposures from power hand tools depend on the amplitude, direction, and frequency spectrum of the tool's vibration during use.

B. Hand-Arm Vibration Syndrome (HAVS)

HAVS is an occupational disease which was first described in 1918.[1] Other names that have been used include occupational Raynaud's phenomenon, and vibration white finger (VWF). The definitive sign of HAVS is the fingertips turning white or "blanching." This results from the constriction of blood vessels that supply the fingertips, usually occurring after exposure to cold temperatures. Symptoms of HAVS include numbness and tingling of the fingers, pain occurring in response to cold exposure and upon return of circulation, and reduction in grip strength and finger dexterity. These symptoms are believed to result from damage to the nerve supply of the hand; however, the exact mechanisms by which vibration effects the nervous and vascular systems are not completely understood. Exposure to cold temperatures and the use of tobacco can contribute to the onset of HAVS and aggravate the symptoms. There are several publications which provide thorough reviews of HAVS.[2,3,4]

C. Exposure criteria

In 1986, the International Standards Organization (ISO) issued ISO 5349, a standard that specifies the method for measurement, data analysis, and reporting of human exposure to HAV. Included with the ISO standard is an estimation of risk from exposures to HAV which is presented in the form of predicted latency periods for different percentiles of the exposed population. For HAV, the latency period refers to the number of years of daily exposure to HAV before the occurrence of the first blanched finger. The predicted latency periods, shown in Figure 1, were based on data in the scientific literature concerning the occurrence of HAVS in various occupational groups. The levels in Figure 1 are acceleration values expressed in units of meters per second squared (m/s^2). HAV is expressed this way because the method available to measure acceleration is better than those available to measure amplitude or velocity, both of which could also be used to describe HAV levels as a function of frequency. Various organizations throughout the world have used ISO 5349, including the predicted latency periods, as a basis for their own evaluation criteria for HAV.

The primary evaluation criteria for workplace exposure to HAV in the United States are the American National Standards Institute (ANSI) Guide for the Measurement and Evaluation of Human Exposure to Vibration Transmitted to the Hand (ANSI S3.34-1986)[5] and the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs) and Biological Exposure Indices for 1993-1994.[6]

ANSI S3.34-1986 specifies the method for measurement, data analysis, and reporting of HAV exposures, and contains two appendices that provide information for interpreting the health risk of HAV exposures. Figure 2, reproduced from the Appendix A of ANSI S3.34-1986, provides exposure duration zones for various HAV levels at different frequencies. Daily exposures above these zones for many years are suspected to cause HAVS. The durations in Figure 2 are for actual tool use, not the length of the workshift.

You can see in Figure 2 that the recommended durations are shorter for exposures at lower frequencies. For example, for an exposure of 20 m/s^2 at frequencies of less than 30 Hertz (Hz), the recommended duration is less than 1/2 hour per day. In contrast, durations of 8 hours or more per day are considered acceptable for an exposure of 20 m/s^2 at 500 Hz. This difference, called frequency weighting, was based on early research which suggested that exposures at lower frequencies were more harmful than those at higher frequencies.[7]

In contrast to the time zones provided in Figure 1, the ACGIH TLVs provided here are single values.

Threshold Limit Values for HAV Exposures

Total Daily Exposure Duration	Values of the Dominant, Frequency-Weighted, rms, Component Acceleration Which Shall not be Exceeded
4 hours and less than 8 hours	4 m/s^2
2 hours and less than 4 hours	6 m/s^2
1 hour and less than 2 hours	8 m/s^2
less than 1 hour	12 m/s^2

These values are used for comparison with measured root mean squared (rms) acceleration levels that have been frequency-weighted from 5.6 to 1400 Hz and then summed according to an equation provided on page 79 of the TLV publication.[6]

Unlike ANSI and ACGIH, NIOSH does not provide a recommended exposure limit because it considers the exposure-response data for HAVS to be insufficient to establish a recommendation that would protect workers.[2] For this reason, NIOSH has stated that the approach to controlling HAVS must be through: 1) medical monitoring to recognize the first signs and symptoms of developing HAVS, 2) medical removal of workers who exhibit signs and symptoms of stage 2 HAVS,[*] 3) engineering controls to minimize the level of vibration produced by tools, 4) establishment of a work regimen to reduce exposure to a feasible minimum, 5) ergonomic design of tools and workplaces, 6) training of workers to recognize and report early signs of HAVS, and 7) supervision to ensure optimal tool maintenance and use.[2]

D. Exposure Measurements

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[*] Stage 2 HAVS refers to Episodic blanching in one or more fingers, intermittent numbness, or reduced tactile perception, to the point where there is interference in work or social activities of the individual.

Acceleration is measured using an accelerometer, a small device that converts mechanical energy into an electrical signal. By measuring this signal and comparing it to a signal from an acceleration source of known magnitude, called a calibration standard, the magnitude of acceleration for the tool can be determined. The electrical signal is integrated over time to provide an average signal called the rms value. The resulting measurement is referred to as the rms acceleration.

The direction of acceleration is determined by attaching accelerometers in the basicentric coordinate system for the hand which is specified in ANSI S3.34-1986 and shown in Figure 3. This system uses the head of the third metacarpal bone as the origin, and defines the Z axis as the longitudinal axis of the bones of the arm, the x axis as perpendicular to the palm of the hand, and the y-axis as passing along the metacarpal bones of the hand.

To determine the frequency spectrum of acceleration, the signal is analyzed with a Fourier spectrum analyzer which can dissect the signal into different frequency ranges, and measure a rms acceleration value for each of those ranges. The frequency ranges specified in ANSI S3.34-1986 are 1/3 octave bands with center frequencies from 6.3 to 1250 Hz.

V. METHODS

HAV exposures were measured for three polishers, two miscellaneous workers, and four bench hands for a total of nine employees. Measurements were made as follows. First, the employee chose two tools which he planned to use on the next mold, and demonstrated how he held each of these two tools. Second, these tools were weighed with a force gauge (Chatillon model DFG50), and each tool's weight, model number, and serial number were recorded. Third, a metal hose clamp, to which a small metal cube with three threaded holes was welded, was attached to the tool handle as near as possible to the employee's hand position without interfering with their use of the tool. Fourth, three piezoelectric accelerometers (PCB model 353A16-A) were screwed into the threaded holes of the metal cube in the basicentric pattern described above. Fifth, the positions of the employee's hands during tool use, the tool attachments used, and the metal composition of the mold (either cast iron or bronze) were recorded.

During tool operation, the signal from the accelerometer traveled through a 10-foot section of cable to an amplifier (PCB model 480D06), then through another 10-foot section of cable to a digital audiotape (DAT) recorder (TEAC model RD-111T) with eight-channel capacity. This capacity allowed for acquisition of signals from all three orthogonal axes of both tools and also voice recording.

The accelerometers were calibrated before and after data collection each day according to the manufacturer's instructions (PCB model 394B05-A calibrator [9.8 m/s^2 signal at 79.6

Hz]) and these calibration signals were recorded for use during analysis. The signal from two of the three accelerometers were monitored with an oscilloscope (Tektronix Model 465) to verify that signal overloading (clipping) was not occurring. The work process was videotaped in synch with data collection in order to compare vibration levels with work processes.

Measurement periods, which will be referred to as "events" in the remainder of this report, ranged from 3 to 71 seconds. Analysis of the recorded measurements was performed at the NIOSH laboratory in Cincinnati, using a fast Fourier transform (FFT) analyzer (Hewlett-Packard Model 35670-A). A schematic representation of data collection and analysis is provided in Figure 4.

Each event was analyzed for either 2, 4, 8, 16, or 32 seconds. The maximum analysis period allowed by the duration of the event was chosen. For example, an event lasting 50 seconds was analyzed during the first 32 seconds, whereas an event lasting only 7 seconds was analyzed for the first 4 seconds. In calculating exposures, we considered analysis results to be representative of the entire event. Analysis provided a rms acceleration value for each 1/3-octave center band frequency from 6.3 to 1250 Hz, for each of the three axes.

Overall weighted values of acceleration (A_{wo}) for each event were calculated using equation B1 of ANSI S 3.34-1986. A_{wo} values were calculated for each axis, and the largest A_{wo} of the three axes was chosen as the A_{wo} for the event. Time-weighted averages (TWAs) for each tool were calculated using equation B4 of ANSI S 3.34-1986. The TWA for each axis was calculated, and the largest TWA of the three axes was chosen as the TWA of the tool. Similarly, TWAs for each employee were calculated using equation B4. This value was the average exposure of the events measured from that employee, and does not include time periods between measurements. Estimates of employees' full-shift durations of exposure were calculated by dividing the duration of tool operation by the total monitoring period, which included periods between measurements, and multiplying this value by 10 hours, the value chosen as the length of a "normal" workshift.

Finally, each employee's TWA was standardized for a 4-hour exposure using equation B5 of ANSI S 3.34-1986. Average 4-hour-equivalent exposures were calculated for the nine employees and also for each of the three job titles. Predicted 50th percentile latency periods were then interpolated from Figure 1.

In an attempt to determine if tools that had the damping material on the handle resulted in significantly lower exposures, the mean exposure level from these tools and the mean level from those without the damping material were compared using a two-sample *t* test for independent samples with equal variances.[8] (The equality of the variances for these two samples was tested using the *F* distribution.) The *t* test was conducted as a 1-tail test with 18 degrees of freedom and a 0.05 level of significance.

VI. RESULTS

Table 1 provides information about the tools that were monitored, including the model and serial numbers, the nominal motor speed, whether it was an in-line or right-angle tool, whether it contained the damping material on the handle, the tools approximate age as reported by the employee, and the weight of the tool and its attachment.

Table 2 provides the A_{wo} values for the x, y, and z axis of each event, the TWAs for each tool, the TWAs for each employee, the estimated full-shift exposure durations, and a conclusion as to whether each employee's estimated exposure was above the ACGIH TLV. A_{wo} values for events ranged from 3.83 to 101 m/s^2. TWAs of the tools ranged from 11 to 66 m/s^2. TWAs for all but two tools were above the ACGIH TLV for one hour, and the TWA of these two tools were above the TLV for two hours. Employees' TWAs ranged from 12 to 56 m/s^2. Calculated estimates of employees' full-shift exposure durations ranged from 2.1 to 5.9 hours per day. Based on these estimates and employees' TWAs, we concluded that each of the nine employees monitored were exposed to HAV levels that are above the ACGIH TLV.

Graphed frequency spectra are provided in Figures 5 through 25. Although each of the 150 events were graphed during analysis, only graphs of those events with the highest A_{wo} for each of the tools are provided with this report. Exposures for 20 of the 21 events cross the 4- to 8-hour zone of Figure 2. Exposures for 5 events crossed the 1- to 2-hour zone. Exposures for 2 events crossed the 1/2- to 1-hour zone. And exposures for 12 events crossed the 1/2-hour zone.

The average 4-hour-equivalent exposure for the nine employees monitored was 28 m/s^2. The average 4-hour-equivalent exposure for polishers was 40 m/s^2. The average 4-hour-equivalent exposure for miscellaneous workers was 32 m/s^2. And the average 4-hour-equivalent exposure for bench hands was 18 m/s^2.

The 50th percentile latency periods predicted from these average exposures were as follows: less than five years for bench hands, less than three years for the whole population and miscellaneous workers, and less than two years for polishers.

Sixteen of the 26 events measured for tool 20 were not included in the calculation of employee and tool TWAs. Analysis results of these 16 events indicated that there were equipment problems during data collection, probably due to the accelerometers not being tightly fixed to the metal cube. The duration of these 16 events were included the full-shift exposure duration of employee 9.

TWA exposures for five employees, 1, 3, 6, 7, and 8, represent exposures for tasks from start to finish. Employee 1, who polished one-half of one mold during the period that he was measured, had a TWA of 56 m/s^2. Employee 3, who rematched the bottom of the two halves of one mold, had a TWA of 13 m/s^2. Employee 6, who removed machine lines from the two halves of one mold, had a TWA of 12 m/s^2. Employee 7, who deburred the edges of the two halves of one mold, had a TWA of 32 m/s^2. Employee 8, who repaired the two halves of one mold had a TWA of 34 m/s^2.

The mean exposure of those tools with the damping material on the handle (17.6 m/s^2) was significantly less than the mean of those without the damping material (31.8 m/s^2) [1-tail, 18 df, α=0.05].

VII. DISCUSSION

The primary objective of this investigation was to determine if employees exposures to HAV represent a health hazard, and to inform the union and the company of this determination. To do this, we needed to know what exposure levels were, and we needed to have evaluation criteria to interpret the health significance of the known exposures.

There were two limitations in the data we collected. First, we monitored nine employees out of a population of 50. Although there is no apparent reason for us to suspect that the exposures of employees who were not monitored would be significantly different than of those employees who were, we cannot be certain that the range of exposures measured is representative of exposures for the entire exposed population. Second, we monitored each employee for brief periods of time, relative to the length of their workshift, on only one day. Again, although there is no apparent reason for us to suspect that the exposures during processes that were not monitored would be significantly different than of those which were monitored, we cannot be certain that the range of exposures measured is representative of exposures for all processes. Furthermore, our estimation of durations of daily tool use may be inaccurate, particularly for those employees who were monitored for shorter periods.

Interpreting the health significance of measured exposures to HAV is difficult because good exposure-response data are lacking. The criteria used in this investigation are estimates of safe exposure levels. Several deficiencies in the data and method used to generate the exposure criteria are discussed in the National Institute of Occupational Health (NIOH) review article.[4] That discussion suggests that the criteria, including the ANSI exposure zones and the ACGIH TLVs, may not accurately estimate safe exposure limits. Furthermore, based on a review of exposure-response data during preparation of the HAV criteria document, NIOSH concluded that unweighted frequency measurements are a more appropriate means of assessing the health risk to exposed workers and that frequency weighting grossly underestimates the HAVS-producing effects from tools that vibrate at high frequencies.[2] The argument for using unweighted data has been made by others as well.[9] Unfortunately, recommended levels for comparing unweighted measurements do not currently exist.

Despite the limitations listed above, we concluded that polishers, miscellaneous workers, and bench hand employees at Ross Mould face a potential hazard from their exposures to HAV. We based this conclusion on the following.

1. Employees are exposed to high levels of HAV relative to currently available evaluation criteria. We measured at least two employees from each of the three job classifications, and the estimated TWA exposures for every employee was above the ACGIH TLV. We measured 21 different tools and the TWAs of 18 of them were above the ACGIH TLV for 1 hour, 2 were above the TLV for 2 hours, and the TWA

of the remaining tool was above the TLV for 4 hours. Finally, predicted 50th percentile latency periods for each job classification were less than five years.

2. Ross Mould does not have a medical monitoring program designed to identify HAVS at an early stage. Without such a program, a case of HAVS is more likely to advance beyond initial stages of disease before being diagnosed. Medical monitoring is useful for identifying hazardous exposures for a variety of agents, but particularly for those like HAV, for which environmental evaluation criteria are currently unavailable or suspect.

3. Employees live in an area where exposure to cold ambient temperatures are common during the winter. Average temperatures in Washington, Pennsylvania during December, January, and February, from 1989 to 1992, were 30, 32, and 32°F respectively. Extreme cold temperatures for 1989, 1990, 1991, and 1992 were -13, 0, 3, and 0°F respectively.[10,11,12,13] Furthermore, employees reported that their hands are exposed to cold from the metal handles of the tools, which are cold during the winter because of the cold air used to provide power to the tools. As mentioned in section VI of this report, finger blanching and pain are associated with cold exposures for victims of HAVS.

VIII. RECOMMENDATIONS

The following recommendations are made to address the potential health hazard from HAV exposures at Ross Mould. A summary of NIOSH recommendations for addressing HAV exposures in general is provided in the "Recommendations for a Standard" section of the NIOSH criteria document.[2]

(1) A medical monitoring program designed for early identification of HAVS should be implemented at Ross Mould. Components of a medical monitoring program that are recommended by NIOSH[2] are included as Attachment 2 of this report.

(2) Employees should be given breaks from HAV exposures. These breaks should be as long and frequent as possible, since this provides an opportunity for recovery. One method of providing breaks from exposure is to rotate employees between jobs which require the use of power hand tools and jobs that do not require their use.

(3) Employees exposed to HAV should be informed of the potential hazards from exposures. Employees should also be taught to grip the tool as lightly as is safely possible, thereby minimizing the coupling of vibration into the hand.

(4) Ross Mould should continue its attempt to replace older tools with new antivibration tools. Information which shows that the new tools significantly reduce vibration during use should be requested from the tool manufacturer.

(5) Ross Mould should investigate the use of gloves as personal protective equipment. Wearing gloves may damp vibration levels from the tool into the hand and can help keep the hands warm. Gloves should be designed to reduce vibration, and must fit well. They should be fitted by a trained individual. An improper fit may result in the employee grasping the tool handle more tightly, resulting in better coupling and a higher exposure. Employees should not be permitted to use gloves with the fingers cut out. Instead, gloves which provide the necessary dexterity in the fingertips, in addition to damping and warmth, should be obtained and used.

(6) In addition to HAVS, the use of vibrating tools may also contribute in causing cumulative trauma disorders (CTDs), such as carpal tunnel syndrome, in jobs where other risk factors for CTDs exist.[3] We did not evaluate other risk factors for CTDs at Ross Mould, however, we did observe that employees repeatedly used their hands to move molds or prepare their tools for use. If an evaluation of risk factors for CTDs is conducted at Ross Mould in the future, HAV exposures should be included in this evaluation.

IX. REFERENCES

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X. AUTHORSHIP and ACKNOWLEDGEMENTS

Report Prepared :	John Kelly, M.S. Industrial Hygienist Industrial Hygiene Section Hazard Evaluations and Technical Assistance Branch Division of Surveillance, Hazard Evaluations and Field Studies
	Pete Fatone, M.S. Mechanical Engineer Applied Psychology and Ergonomics Branch Division of Biomedical and Behavioral Science
Field Assistance:	Randy L. Tubbs, Ph.D. Psychoacoustician Industrial Hygiene Section Hazard Evaluations and Technical Assistance Branch Division of Surveillance, Hazard Evaluations and Field Studies

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Originating Office: Hazard Evaluations and Technical Assistance Branch
Division of Surveillance, Hazard Evaluations and Field Studies
National Institute for Occupational Safety and Health 4676 Columbia Parkway
Cincinnati, Ohio 45226

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Copies of this report have been sent to:

1. Ross Mould
2. AFGW local 146
3. Occupational Safety and Health Administration, Region III

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Table 1: Tool Information
Ross Mould
Washington, Pennsylvania
3/22/94 - 3/23/94
HETA 93-510

Tool #	Make	Model Number	Serial Number	Motor Speed (rpm)	In-line or Right Angle	Damping Handle	Approx. Tool Age (months)	Tool Wt. (lbs)
1	Dotco	10L1201-36	140518	20,000	right angle	no	1	1.5
2	Dotco	10L250001	422738	23,000	in-line	no	36	2.0
3	Dotco	10L1000A36	D15311	30,000	in-line	no	24	1.1
4	Dotco	10L1000A36	D15310	30,000	in-line	no	24	1.6
5	Dotco	10L1000A36	710894	30,000	in-line	no	30	1.0
6	Dotco	12L120138	23771	20,000	right angle	yes	24	1.7
7	Dotco	12L100036	N21918	30,000	in-line	yes	14	1.4
8	Dotco	10L100036	030854	30,000	in-line	no	1	1.3
9	Dotco	12L120136	N23767	20,000	right angle	yes	14	1.6
10	Dotco	10L1101B36	576110	28,000	in-line	no	48	1.8
11	Dotco	10L100A36	D15303	30,000	in-line	no	30	1.5
12	Dotco	10L100036	624730	30,000	in-line	no	18	1.2
13	Dotco	10L1101-36	733206	28,000	in-line	no	12	1.8
14	Engis	-	B900096	10,000	right angle	no	24	1.7
15	Dotco	10L1000A36	812173	30,000	in-line	no	24	1.0
16	Dotco	12L1201-36	130478	20,000	right angle	yes	18	1.7
17	Dotco	12L100036	N21920	30,000	in-line	yes	15	1.2
18	Dotco	10L2500C01	545404	23,000	in-line	no	96	2.0
19	Dotco	10L1101B36	505718	28,000	in-line	no	not reported	1.8
20	Dotco	10L1000-36	733684	30,000	in-line	no	7	1.3
21	Dotco	10L1201-36	032331	20,000	right angle	no	not reported	1.7

Table 2: Vibration Measurement Results
Ross Mould
Washington, Pennsylvania
3/22/94 - 3/23/94
HETA 93-510

EMPLOYEE # 1. POLISHER. 3/22/94

Tool #	Tool Attachment	Measurement Number	Measurement Duration (seconds[s])	A_{wo} (m/s2) x axis	A_{wo} (m/s2) y axis	A_{wo} (m/s2) z axis	Conclusion
1	1" diameter abrasive disc	1	19	15.1	13.4	12.6	This employee was monitored for 19.7 minutes ('). During this time he operated the tool for 8.7'. The estimated time period which this employee operates pneumatic tools during a 10-hour (h) workshift is 4.4 h [(8.7/19.7) x 600' x (1h/60')]. The ACGIH TLV is less than 1 hour for exposures equal to or greater than 12 m/s2. This employee's TWA was 56 m/s2. **Therefore, this employee's estimated daily exposure to HAV was above the ACGIH TLV.**
	" with new paper	2	39	16.8	18.3	16.1	
	TWA - tool		*58*	16.3	16.9	15.0	
2	cylindrical sanding bit	1	4	42.1	50.7	28.2	
	TWA - tool		*4*	42.1	50.7	28.2	
3	1/2" diameter ball with abrasive paper	1	33	28.1	19.8	21.8	
	" with new paper	2	46	37.6	26.8	30.1	
	" with new paper	3	31	29.0	26.5	27.6	
	" with new paper	4	21	29.2	25.9	29.5	
	" with new paper	5	68	101	51.5	71.6	
	" with new paper	6	71	56.0	33.2	36.4	
	" with new paper	7	50	74.3	36.5	46.4	
	" with new paper	8	38	75.1	36.8	51.7	
	TWA - tool		*356*	65.5	35.8	45.8	
4	1" rubber ball with abrasive paper	1	22	20.2	23.2	32.3	
	"	2	40	26.2	31.4	33.8	
	abrasive brush and a 4" extension	3	37	29.0	35.5	35.6	
	TWA - tool		*99*	26.1	31.5	34.2	
	TWA - employee		*519*	**56.0**	**33.5**	**41.2**	

Values in italics are summed durations for tool or employee measurements.
Underlined values are time weighted averages (TWAs) for the tool.
Values in bold are TWAs for the employee

Table 1: Tool Information
Ross Mould
Washington, Pennsylvania
3/22/94 - 3/23/94
HETA 93-510

Tool #	Make	Model Number	Serial Number	Motor Speed (rpm)	In-line or Right Angle	Damping Handle	Approx. Tool Age (months)	Tool Wt. (lbs)
1	Dotco	10L1201-36	140516	20,000	right angle	no	1	1.5
2	Dotco	10L250001	422738	23,000	in-line	no	38	2.0
3	Dotco	10L1000A36	D15311	30,000	in-line	no	24	1.1
4	Dotco	10L1000A36	D15310	30,000	in-line	no	24	1.6
5	Dotco	10L1000A36	710894	30,000	in-line	no	30	1.0
6	Dotco	12L120136	23771	20,000	right angle	yes	24	1.7
7	Dotco	12L100036	N21916	30,000	in-line	yes	14	1.4
8	Dotco	10L100036	030854	30,000	in-line	no	1	1.3
9	Dotco	12L120136	N23767	20,000	right angle	yes	14	1.6
10	Dotco	10L1101B36	578110	28,000	in-line	no	48	1.8
11	Dotco	10L100A36	D15303	30,000	in-line	no	30	1.5
12	Dotco	10L100036	624730	30,000	in-line	no	18	1.2
13	Dotco	10L1101-36	733206	28,000	in-line	no	12	1.8
14	Engis	-	B900096	10,000	right angle	no	24	1.7
15	Dotco	10L1000A36	812173	30,000	in-line	no	24	1.0
16	Dotco	12L1201-36	130478	20,000	right angle	yes	18	1.7
17	Dotco	12L100036	N21920	30,000	in-line	yes	15	1.2
18	Dotco	10L2500C01	545404	23,000	in-line	no	96	2.0
19	Dotco	10L1101B36	505716	28,000	in-line	no	not reported	1.8
20	Dotco	10L1000-36	733684	30,000	in-line	no	7	1.3
21	Dotco	10L1201-36	032331	20,000	right angle	no	not reported	1.7

Table 2: Vibration Measurement Results
Ross Mould
Washington, Pennsylvania
3/22/94 - 3/23/94
HETA 93-510

EMPLOYEE # 2, MISCELLANEOUS, 3/22/94

Tool #	Tool Attachment	Measurement Number	Measurement Duration (seconds[s])	A_{wo} (m/s2) x axis	A_{wo} (m/s2) y axis	A_{wo} (m/s2) z axis	Conclusion
5	small metal deburring surface	1	9	46.3	28.5	37.5	This employee was monitored for 5.1 minutes ('). During this time he operated the tool for 2.3'. The estimated time period which this employee operates pneumatic tools during a 10-hour (h) workshift is 4.5 h [(2.3/5.1) x 600' x (1h/60')]. The ACGIH TLV is less than 1 hour for exposures equal to or greater than 12 m/s2. This employee's TWA was 31 m/s2. **Therefore, this employee's estimated daily exposure to HAV was above the ACGIH TLV.**
	"	2	4	41.8	24.6	34.7	
	"	3	7	44.9	25.3	34.4	
	TWA - tool		*20*	44.9	26.6	35.9	
6	1" diameter abrasive disc	1	5	12.9	11.3	31.4	
	"	2	5	11.1	9.7	29.3	
	"	3	55	11.4	11.3	29.9	
	"	4	45	12.7	11.1	28.8	
	"	5	5	11.8	11.2	31.0	
	"	6	4	14.1	9.7	28.5	
	TWA - tool		*119*	12.1	11.1	29.6	
	TWA - employee		*139*	20.4	14.4	30.5	

Values in italics are summed durations for tool or employee measurements.
Underlined values are time weighted averages (TWAs) for the tool.
Values in bold are TWAs for the employee

Table 2: Vibration Measurement Results
Ross Mould
Washington, Pennsylvania
3/22/94 - 3/23/94
HETA 93-510

EMPLOYEE # 3, BENCH HAND, 3/22/94

Tool #	Tool Attachment	Measurement Number	Measurement Duration (seconds[s])	A_{wo} (m/s2) x axis	A_{wo} (m/s2) y axis	A_{wo} (m/s2) z axis	Conclusion
7	1" diameter brush	1	6	7.60	7.58	9.47	This employee was monitored for 22.3 minutes ('). During this time he operated the tool for 3.7'. The estimated time period which this employee operates pneumatic tools during a 10-hour (h) workshift is 1.7 h [(3.7/22.3) x 600' x (1h/60')]. The ACGIH TLV is <u>less than 1 hour</u> for exposures equal to or greater than 12 m/s2. This employee's TWA was 13 m/s2. **Therefore, this employee's estimated daily exposure to HAV was above the ACGIH TLV.**
	"	2	6	6.26	7.93	6.82	
	"	3	5	9.37	12.1	11.9	
	"	4	12	10.2	14.3	12.8	
	"	5	4	7.02	7.91	6.79	
	<u>TWA - tool</u>		*33*	8.64	<u>11.2</u>	10.6	
8	1/2" diameter ball with abrasive paper	1	11	8.53	9.28	9.14	
	"	2	7	9.60	10.8	11.4	
	"	3	29	9.09	8.67	10.6	
	"	4	15	9.40	9.55	10.4	
	"	5	8	12.1	12.1	13.6	
	"	6	42	15.6	13.7	15.2	
	"	7	12	30.3	26.2	24.2	
	<u>TWA - tool</u>		*124*	<u>14.9</u>	13.5	14.2	
9	1" diameter abrasive disc	1	13	6.43	2.78	10.0	
	"	2	9	5.47	2.85	6.28	
	"	3	7	6.77	6.36	16.6	
	"	4	18	6.59	3.18	8.90	
	"	5	20	9.10	4.66	11.4	
	<u>TWA - tool</u>		*67*	7.30	4.00	<u>10.6</u>	
	TWA - employee		*224*	**12.3**	**11.2**	**12.7**	

Values in italics are summed durations for tool or employee measurements.
Underlined values are time weighted averages (TWAs) for the tool.
Values in bold are TWAs for the employee

Table 2: Vibration Measurement Results
Ross Mould
Washington, Pennsylvania
3/22/94 - 3/23/94
HETA 93-510

EMPLOYEE # 4, BENCH HAND, 3/22/94

Tool #	Tool Attachment	Measurement Number	Measurement Duration (seconds[s])	A_{wo} (m/s2) x axis	A_{wo} (m/s2) y axis	A_{wo} (m/s2) z axis	Conclusion
10	3" diameter brush and extension	1	13	16.8	18.0	11.3	This employee was monitored for 7.8 minutes ('). During this time he operated the tool for 1.8'. The estimated time period which this employee operates pneumatic tools during a 10-hour (h) workshift is 2.4 h [(1.8/7.8) x 600' x (1h/60')]. The ACGIH TLV is <u>less than 1 hour</u> for exposures equal to or greater than 12 m/s2. This employee's TWA was 13 m/s2. **Therefore, this employee's estimated daily exposure to HAV was above the ACGIH TLV.**
	"	2	8	15.2	17.3	12.1	
	"	3	20	14.1	15.0	10.5	
	"	4	4	17.0	17.4	12.4	
	<u>TWA - tool</u>		*45*	15.3	<u>16.5</u>	11.2	
11	2" ball with abrasive paper and extension	1	20	7.96	8.38	11.4	
	"	2	15	7.25	7.41	9.67	
	"	3	10	10.7	12.4	15.2	
	"	4	20	10.2	13.3	13.4	
	<u>TWA - tool</u>		*65*	9.03	10.6	<u>12.4</u>	
"	**TWA - employee**		*110*	12.0	**13.3**	11.9	

Values in italics are summed durations for tool or employee measurements.
Underlined values are time weighted averages (TWAs) for the tool.
Values in bold are TWAs for the employee

Table 2: Vibration Measurement Results
Ross Mould
Washington, Pennsylvania
3/22/94 - 3/23/94
HETA 93-510

EMPLOYEE # 5, POLISHER, 3/22/94

Tool #	Tool Attachment	Measurement Number	Measurement Duration (seconds[s])	A_{wo} (m/s2) x axis	A_{wo} (m/s2) y axis	A_{wo} (m/s2) z axis	Conclusion
12	1" diameter brush	1	33	33.1	21.0	27.2	This employee was monitored for 11.6 minutes ('). During this time he operated the tool for 6.4'. The estimated time period which this employee operates pneumatic tools during a 10-hour (h) workshift is 5.5 h [(6.4/11.6) x 600' x (1h/60')]. The ACGIH TLV is <u>less than 1 hour</u> for exposures equal to or greater than 12 m/s2. This employee's TWA was 32 m/s2. **Therefore, this employee's estimated daily exposure to HAV was above the ACGIH**
	"	2	38	32.5	20.8	29.0	
	"	3	35	33.2	21.5	31.9	
	"	4	50	31.5	20.2	32.5	
	"	5	41	33.3	24.0	34.1	
	<u>TWA - tool</u>		*197*	<u>32.7</u>	21.5	31.3	
13	1/2" diameter ball with abrasive paper	1	48	22.9	15.4	22.9	
	" with new paper	2	43	27.6	19.2	19.3	
	" with new paper	3	47	34.1	24.4	23.6	
	" with new paper	4	51	39.2	25.5	24.7	
	<u>TWA - tool</u>		*189*	<u>31.8</u>	21.6	22.8	
	TWA - employee		*386*	32.3	21.6	27.5	

Values in italics are summed durations for tool or employee measurements
Underlined values are time weighted averages (TWAs) for the tool.
Values in bold are TWAs for the employee

Table 2: Vibration Measurement Results
Ross Mould
Washington, Pennsylvania
3/22/94 - 3/23/94
HETA 93-510

EMPLOYEE # 6, BENCH HAND, 3/23/94

Tool #	Tool Attachment	Measurement Number	Measurement Duration (seconds[s])	A_{wo} (m/s2) x axis	A_{wo} (m/s2) y axis	A_{wo} (m/s2) z axis	Conclusion
14	8" long grinding stone	1	63	6.52	7.38	7.44	This employee was monitored
	"	2	40	11.3	12.3	13.0	for 17.4 minutes ('). During
	"	3	27	3.55	3.53	6.66	this time he operated the tool for
	"	4	61	6.55	15.3	10.7	10.3'. The estimated time
	"	5	55	8.00	16.6	21.2	period which this employee
	"	6	14	4.68	6.21	7.12	operates pneumatic tools during
	"	7	52	4.64	6.87	9.10	a 10-hour (h) workshift is 5.9 h
	"	8	29	5.21	8.46	9.89	[(10.3/17.4) x 600' x (1h/60')]
	"	9	32	5.78	8.02	9.88	The ACGIH TLV is <u>less than 1</u>
	"	10	67	5.38	8.44	7.88	<u>hour</u> for exposures equal to or
	"	11	32	6.48	8.89	16.4	greater than 12 m/s2. This
	"	12	54	8.67	11.1	18.7	employee's TWA was 12 m/s2
	"	13	30	5.02	6.59	8.01	**Therefore, this employee's**
	"	14	61	6.23	6.77	10.6	**estimated daily exposure to**
	<u>TWA - tool</u>		*617*	6.74	10.2	<u>12.4</u>	**HAV was above the ACGIH**
	TWA - employee		*617*	**6.74**	**10.2**	**12.4**	**TLV.**

Values in italics are summed durations for tool or employee measurements
Underlined values are time weighted averages (TWAs) for the tool.
Values in bold are TWAs for the employee

Table 2: Vibration Measurement Results
Ross Mould
Washington, Pennsylvania
3/22/94 - 3/23/94
HETA 93-510

EMPLOYEE # 7, MISCELLANEOUS, 3/23/94

Tool #	Tool Attachment	Measurement Number	Measurement Duration (seconds[s])	A_{wo} (m/s2) x axis	A_{wo} (m/s2) y axis	A_{wo} (m/s2) z axis	Conclusion
15	1' diameter abrasive disc	1	5	46.5	24.2	34.0	This employee was monitored for 8.6 minutes ('). During this time he operated the tool for 3.2'. The estimated time period which this employee operates pneumatic tools during a 10-hour (h) workshift is 3.7 h [(3.2/8.6) x 600' x (1h/60')]. The ACGIH TLV is <u>less than 1 hour</u> for exposures equal to or greater than 12 m/s2. This employee's TWA was 32 m/s2. **Therefore, this employee's estimated daily exposure to HAV was above the ACGIH TLV.**
	"	2	4	46.3	23.6	35.1	
	"	3	3	41.2	22.9	31.8	
	"	4	15	39.3	14.8	40.2	
	"	5	4	33.5	9.80	28.3	
	"	6	3	37.6	11.5	36.1	
	"	7	15	31.6	18.5	40.0	
	1/2" diameter deburring stone	8	32	35.2	11.2	34.1	
	"	9	19	32.2	15.8	40.4	
	"	10	22	33.1	11.1	37.6	
	"	11	13	30.8	15.5	42.8	
	<u>TWA - tool</u>		*135*	35.2	15.0	<u>37.7</u>	
16	1" abrasive disc	1	29	21.2	20.6	11.6	
	"	2	27	20.1	19.1	12.1	
	<u>TWA - tool</u>		*56*	<u>20.7</u>	19.9	11.9	
	TWA - employee		*191*	31.6	16.6	**32.4**	

Values in italics are summed durations for tool or employee measurements
Underlined values are time weighted averages (TWAs) for the tool.
Values in bold are TWAs for the employee

Table 2: Vibration Measurement Results
Ross Mould
Washington, Pennsylvania
3/22/94 - 3/23/94
HETA 93-510

EMPLOYEE # 8, BENCH HAND, 3/23/94

Tool #	Tool Attachment	Measurement Number	Measurement Duration (seconds[s])	A_{wo} (m/s2) x axis	y axis	z axis	Conclusion
17	1" abrasive disc	1	30	15.5	9.79	12.1	This employee was monitored for 4.1 minutes ('). During this time he operated the tool for 2.2'. The estimated time period which this employee operates pneumatic tools during a 10-hour (h) workshift is 5.4 h [(2.2/4.1) x 600' x (1h/60')]. The ACGIH TLV is less than 1 hour for exposures equal to or greater than 12 m/s2. This employee's TWA was 34 m/s2. **Therefore, this employee's estimated daily exposure to HAV was above the ACGIH TLV.**
		2	11	17.2	9.05	8.48	
	TWA - tool		*41*	16.0	9.59	11.2	
18	1/2" diameter ball with abrasive paper	1	15	43.5	41.4	37.2	
	"	2	8	41.0	38.1	33.4	
	2" diameter brush	3	8	53.5	47.2	40.9	
	"	4	11	59.5	52.4	43.8	
	"	5	10	59.8	51.3	34.1	
	TWA - tool		*52*	51.8	46.3	38.2	
19	1/2" diameter ball with abrasive paper	1	20	3.83	3.03	2.85	
"	"	2	21	5.80	4.35	3.53	
	TWA - tool		*41*	4.94	3.76	3.22	
	TWA - employee		*134*	**33.6**	**29.4**	**24.6**	

Values in italics are summed durations for tool or employee measurements
Underlined values are time weighted averages (TWAs) for the tool.
Values in bold are TWAs for the employee

Table 2: Vibration Measurement Results
Ross Mould
Washington, Pennsylvania
3/22/94 - 3/23/94
HETA 93-510

EMPLOYEE # 9, POLISHER, 3/23/94

Tool #	Tool Attachment	Measurement Number	Measurement Duration (seconds[s])	A_{wo} (m/s2) x axis	A_{wo} (m/s2) y axis	A_{wo} (m/s2) z axis	Conclusion
20	1" diameter ball with abrasive paper	1	26	13.6	6.70	11.6	This employee was monitored for 29.1 minutes ('). During this time he operated the tool for 8.0'.* The estimated time period which this employee operates pneumatic tools during a 10-hour (h) workshift is 3.7 h [(10.7/29.1) x 600' x (1h/60')]. The ACGIH TLV is <u>less than 1 hour</u> for exposures equal to or greater than 12 m/s2. This employee's TWA was 29 m/s2. **Therefore, this employee's estimated daily exposure to HAV was above the ACGIH TLV.** * 10.7' includes the 16 events measured for tool 20 that were not included in the calculation of TWA exposures because of problems during data collection.
	"	2	19	18.2	14.8	22.6	
	" with new paper	7	17	32.9	38.4	50.2	
	" with new paper and longer extension	12	14	15.5	12.8	17.0	
	1/2" diameter abrasive and small extensio	13	17	17.9	20.4	19.7	
	"	15	15	21.4	17.2	18.5	
	"	16	10	19.8	18.3	16.9	
	2" brush	21	17	15.5	17.9	19.5	
	"	22	11	15.3	13.6	15.4	
	1" brush	23	12	19.6	24.1	22.8	
	"	24	18	22.4	25.4	25.6	
	2" brush	25	10	19.2	22.3	23.3	
	"	26	19	20.8	20.7	21.9	
	<u>TWA - tool</u>		*205*	<u>19.9</u>	<u>20.6</u>	<u>23.8</u>	
21	1" abrasive disc	1	40	31.7	25.7	19.5	
	" with new paper	2	55	35.6	28.9	19.1	
	" with new paper	3	38	43.7	28.4	17.6	
	" with new paper	4	23	43.9	25.8	17.5	
	"	5	6	29.3	17.8	11.7	
	<u>TWA - tool</u>		*162*	<u>37.8</u>	<u>27.3</u>	<u>18.4</u>	
	TWA - employee		*367*	**29.2**	**23.8**	**21.6**	

Values in italics are summed durations for tool or employee measurements
Underlined values are time weighted averages (TWAs) for the tool.
Values in bold are TWAs for the employee

Figure 1: Latency Periods for HAVS
(taken from ISO 5349-1986)
HETA 93-510
Ross Mould
Washington, Pennsylvania

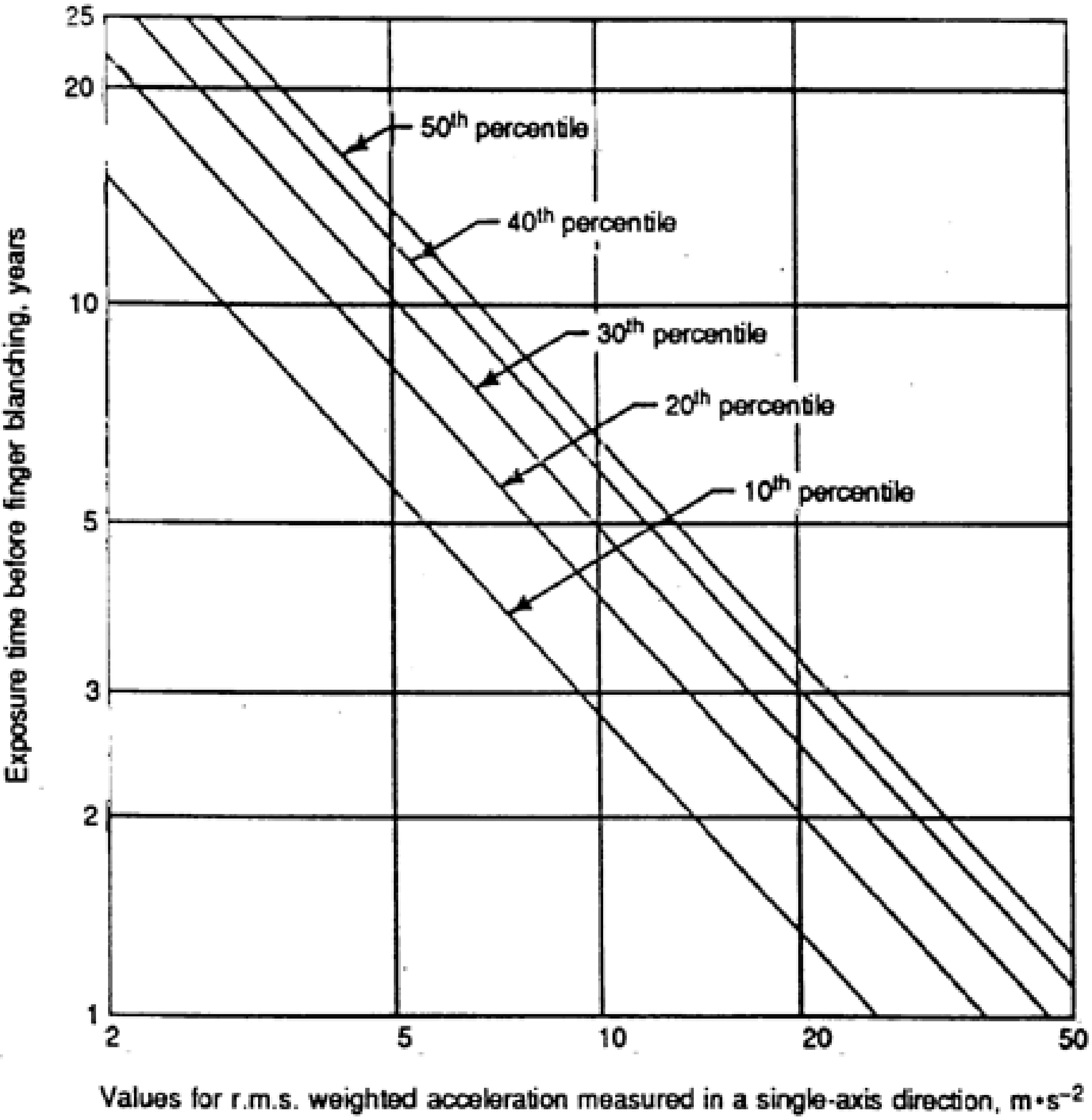

Figure 2: Vibration Exposure Zones
(taken from ANSI S 3.34-1986)
HETA 93-510
Ross Mould
Washington, Pennsylvania

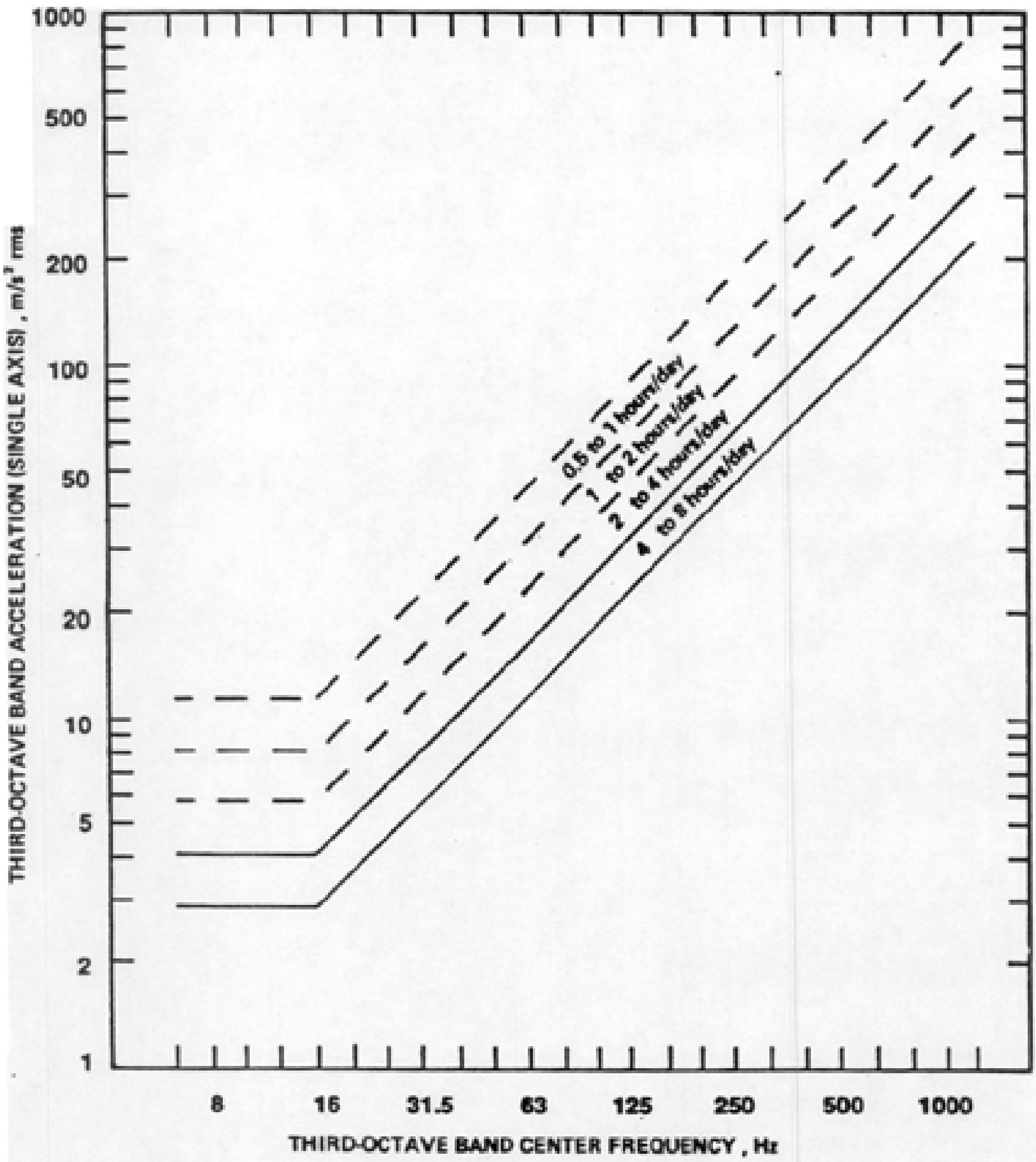

FIG. A1. Vibration exposure zones for the assessment of hand-transmitted vibration. The zones of daily exposure time are for rms accelerations of discrete frequency vibration and for narrow-band or broadband vibration analyzed as third-octave band rms acceleration. The values are for the dominant single axis vibration generating compression of the flesh of the hand. The values are for regular daily exposure and for good coupling of the hand to the vibration source.

Figure 3: Basicentric Coordinate System
HETA 93-510
Ross Mould
Washington, Pennsylvania

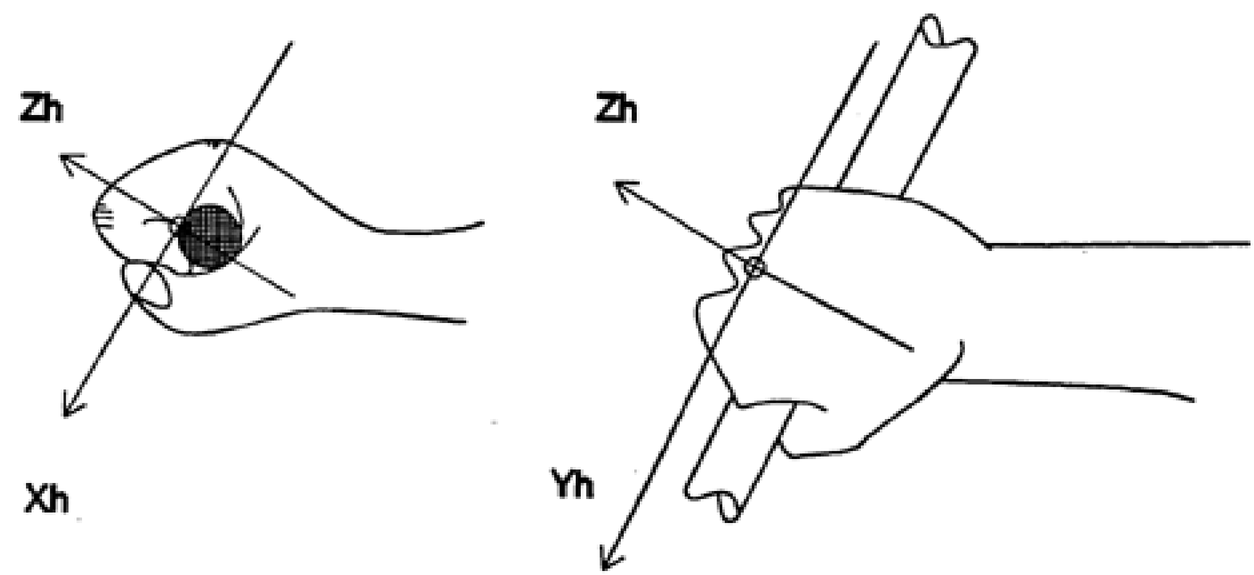

Figure 4: Data Collection and Analysis System
HETA 93-510
Ross Mould
Washington, Pennsylvania

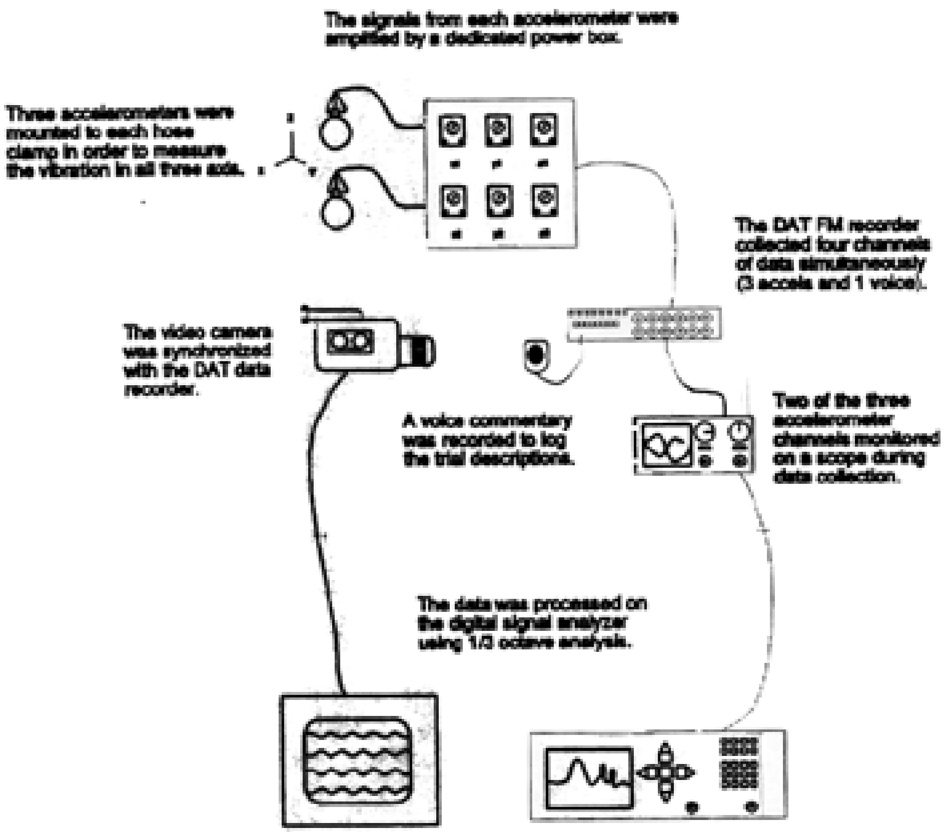

Figure 5 Frequency Spectra of Tool Acceleration Levels for Tool 1
HETA 93-510
Ross Mould
Washington, Pennsylvania

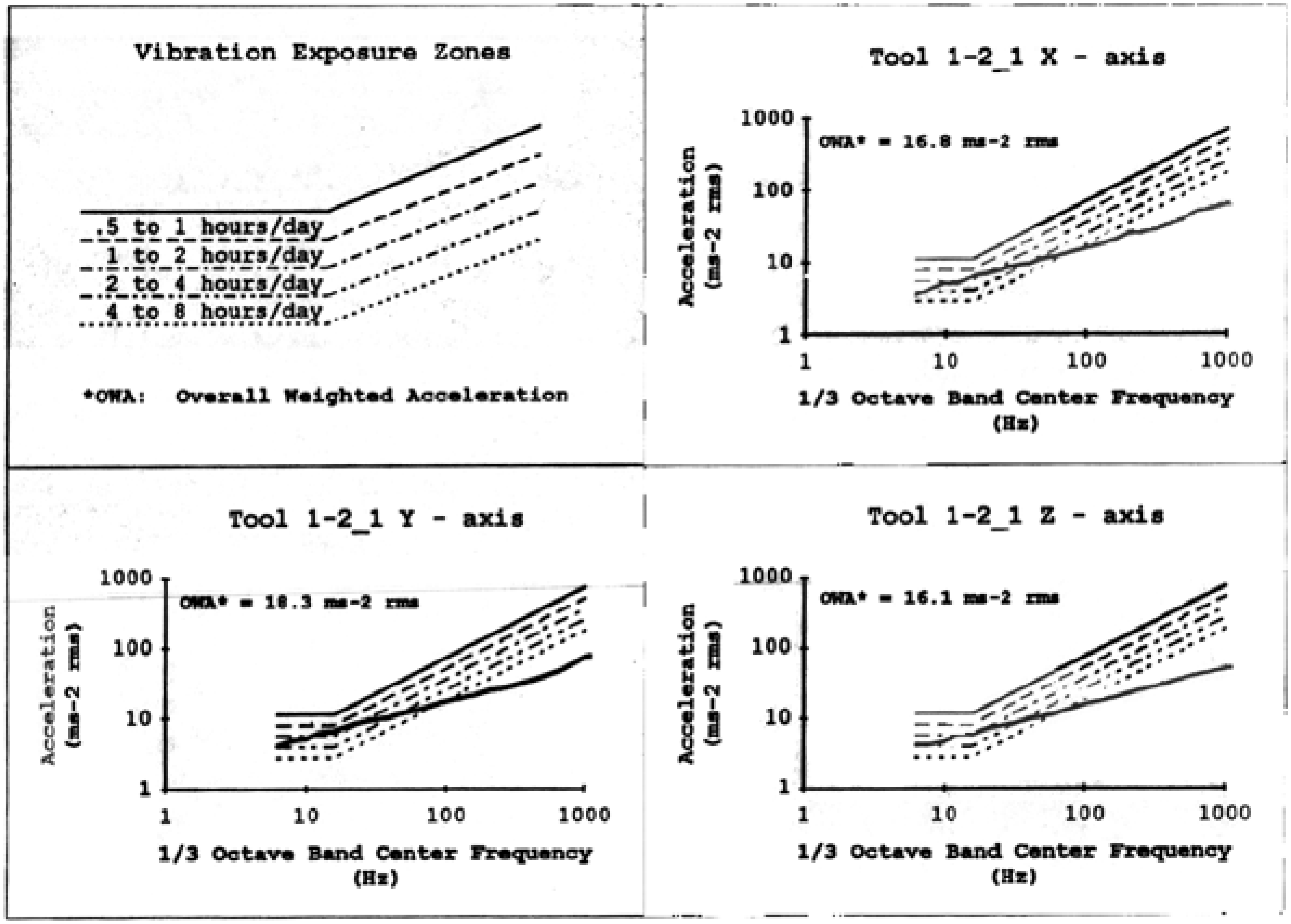

Figure 6: Frequency Spectra of Tool Acceleration Levels for Tool 2
HETA 93-510
Ross Mould
Washington, Pennsylvania

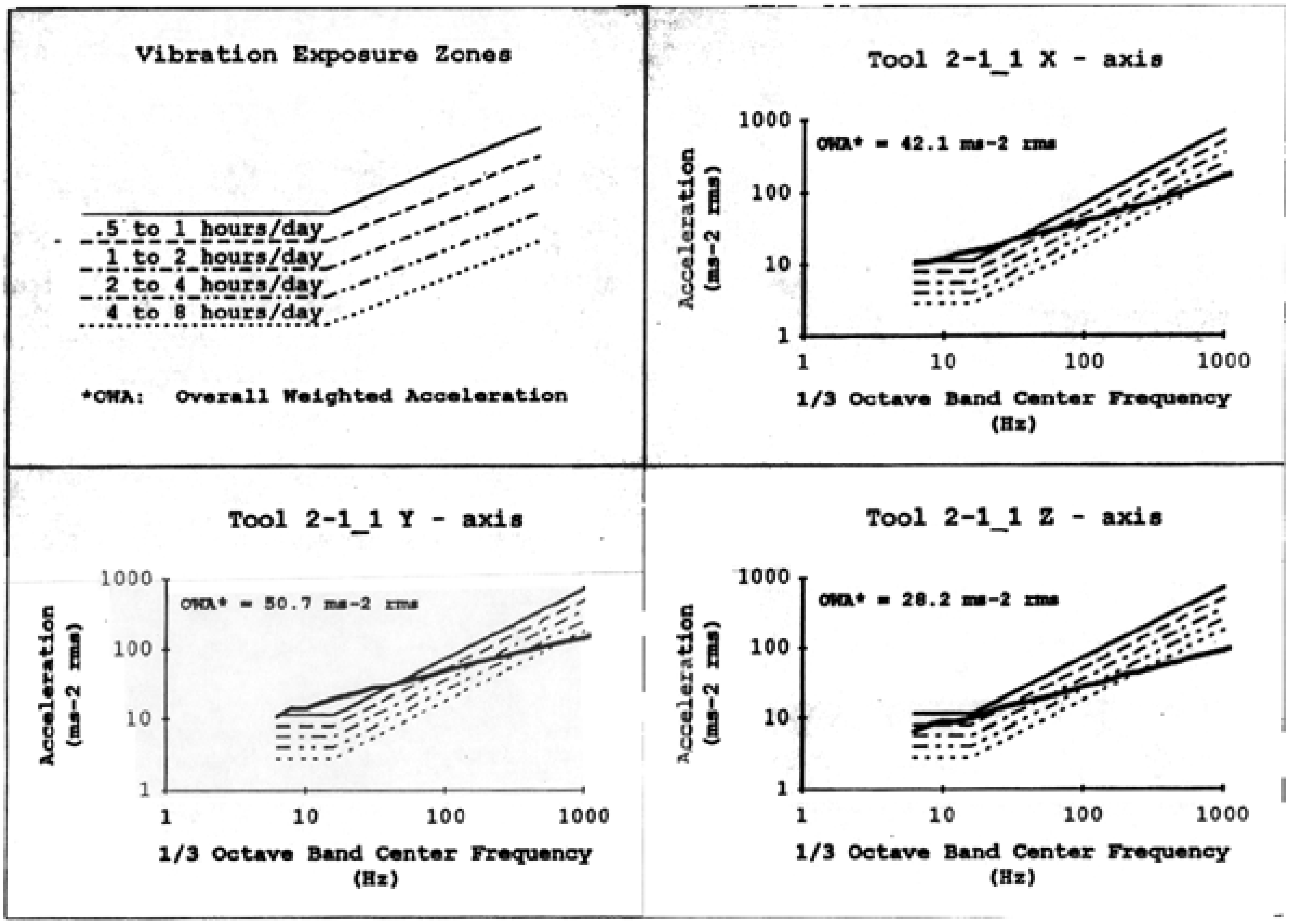

Figure 7: Frequency Spectra of Tool Acceleration Levels for Tool 3
HETA 93-510
Ross Mould
Washington, Pennsylvania

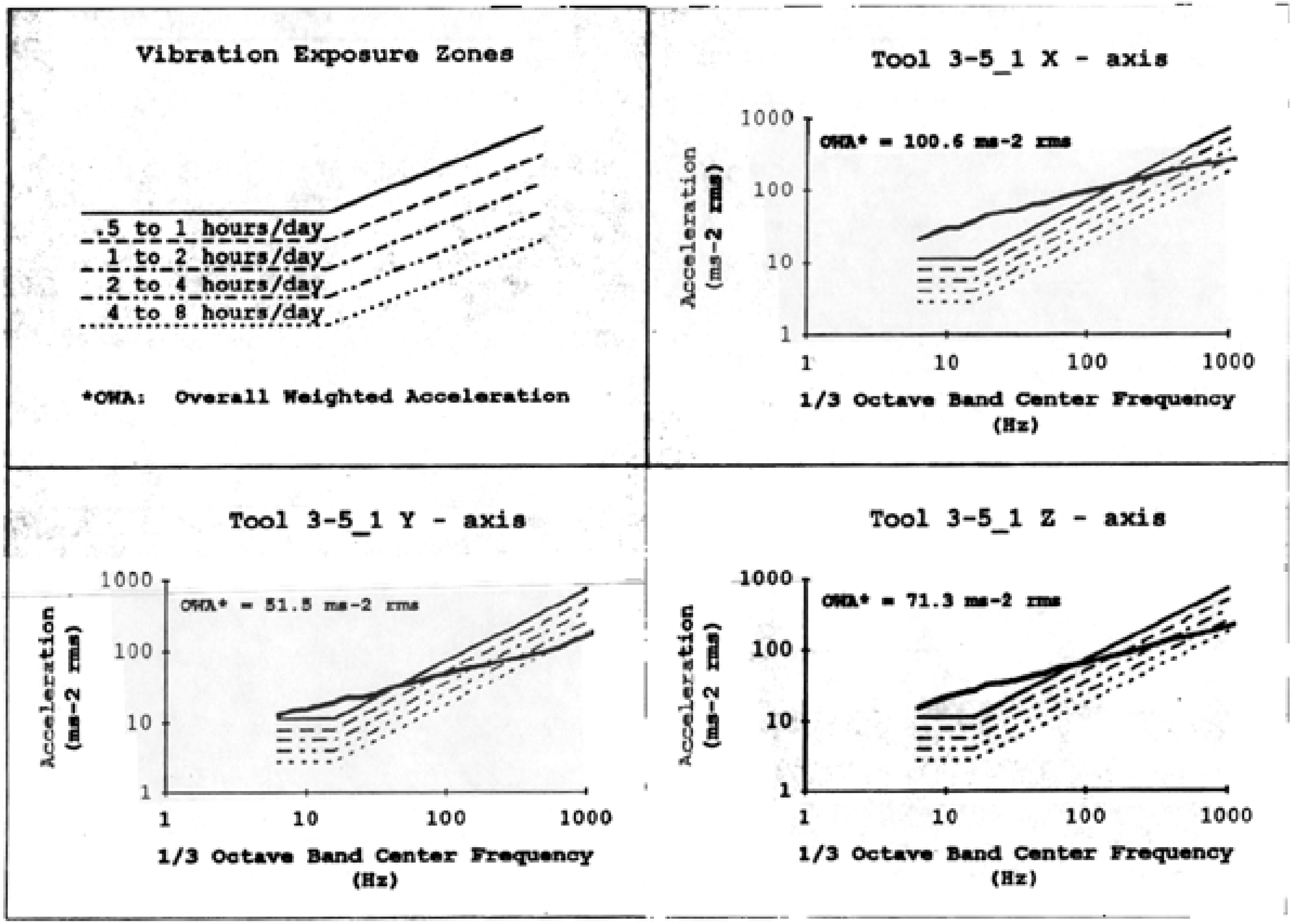

Figure 8: Frequency Spectra of Tool Acceleration Levels for Tool 4
HETA 93-510
Ross Mould
Washington, Pennsylvania

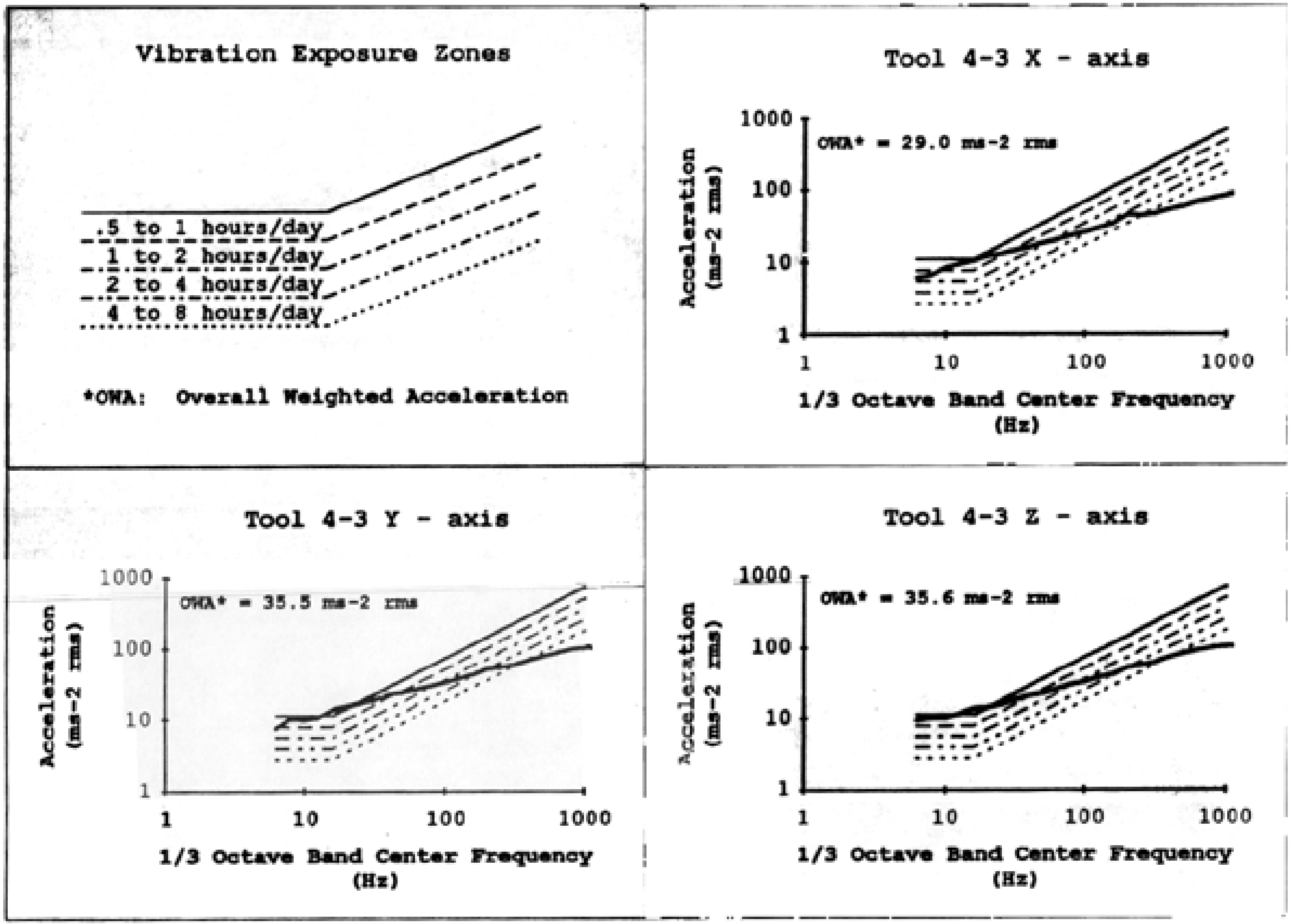

Figure 9: Frequency Spectra of Tool Acceleration Levels for Tool 5
HETA 93-510
Ross Mould
Washington, Pennsylvania

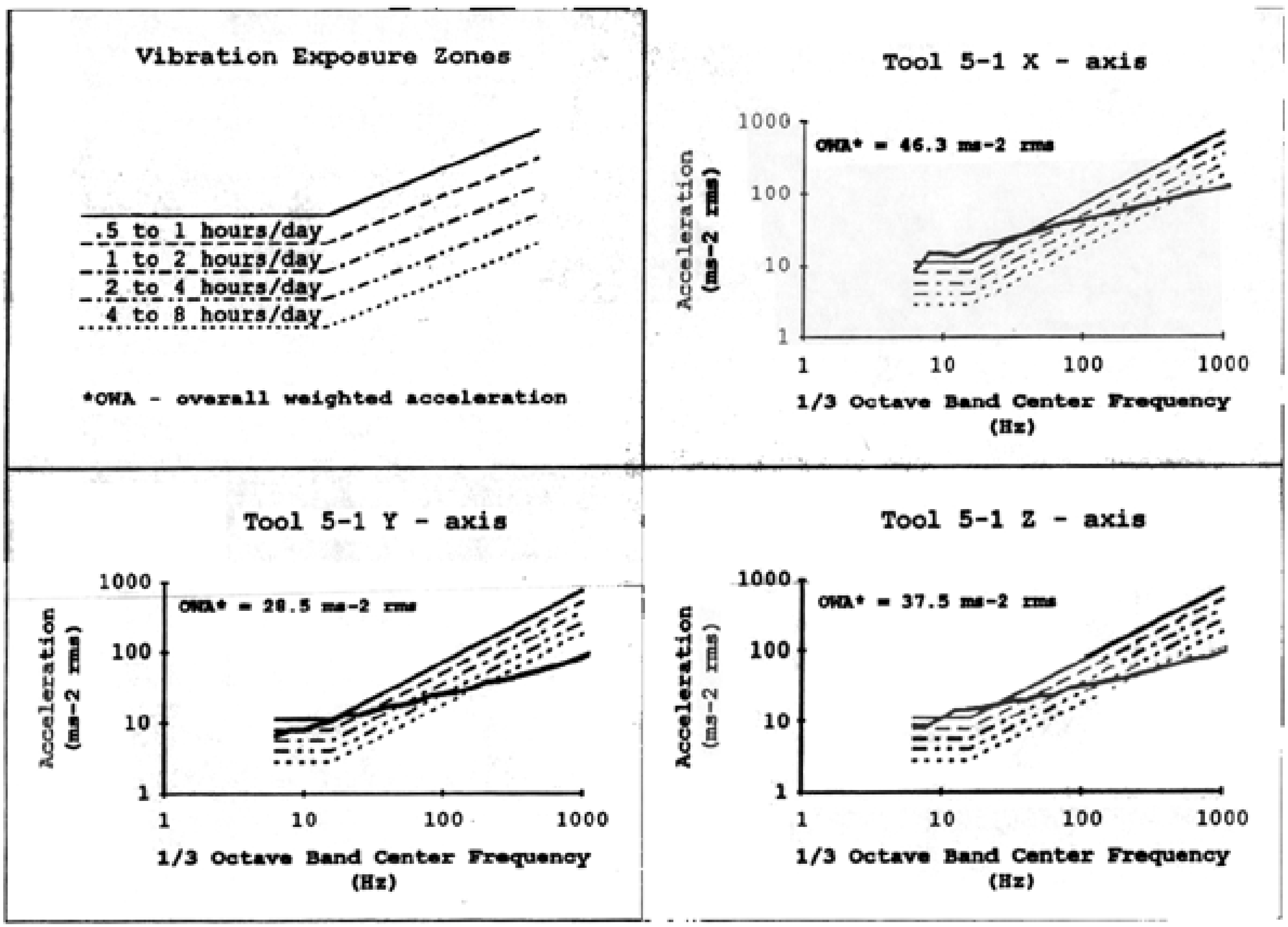

Figure 10: Frequency Spectra of Tool Acceleration Levels for Tool 6
HETA 93-510
Ross Mould
Washington, Pennsylvania

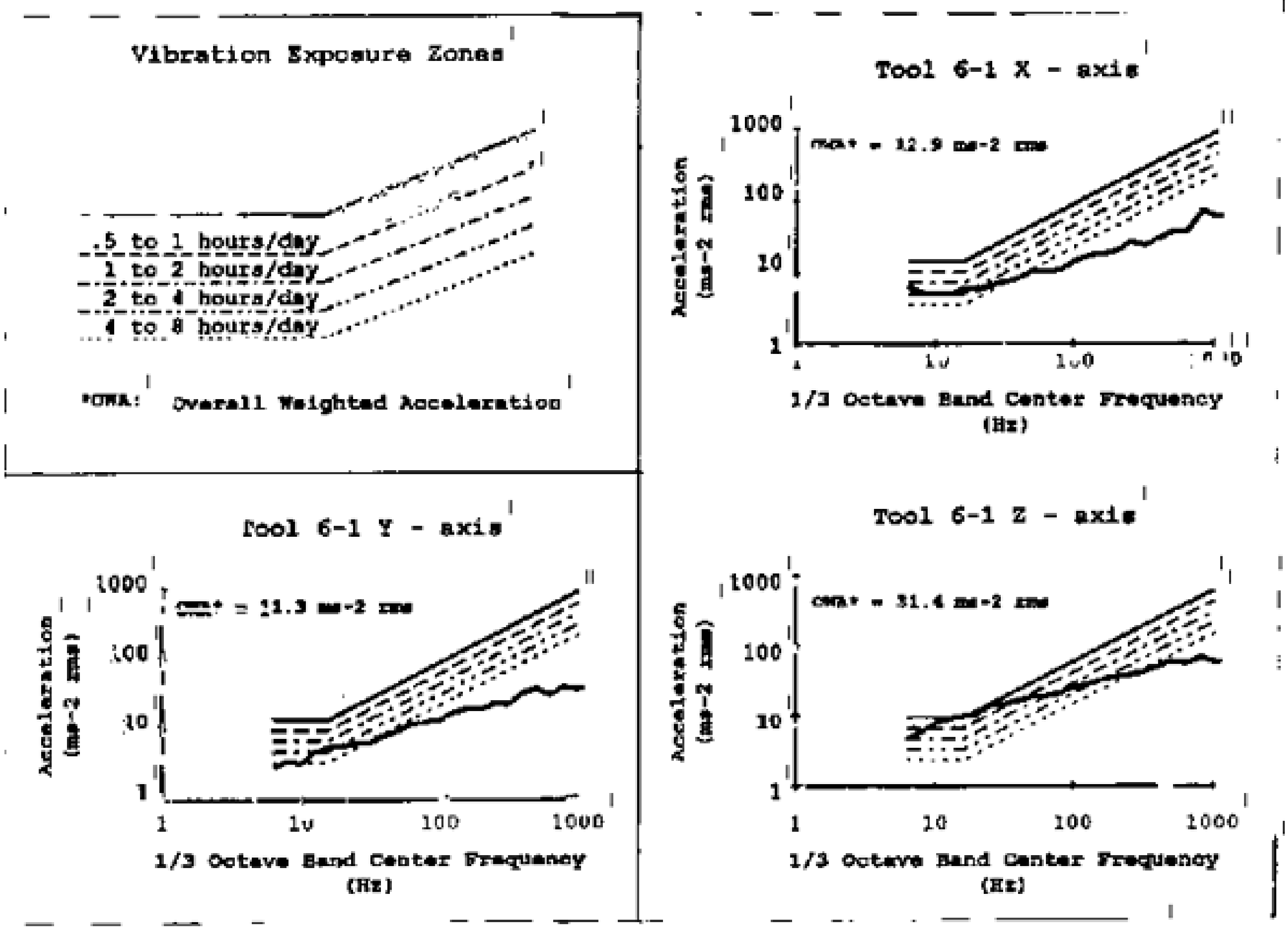

Figure 11: Frequency Spectra of Tool Acceleration Levels for Tool 7
HETA 93-510
Ross Mould
Washington, Pennsylvania

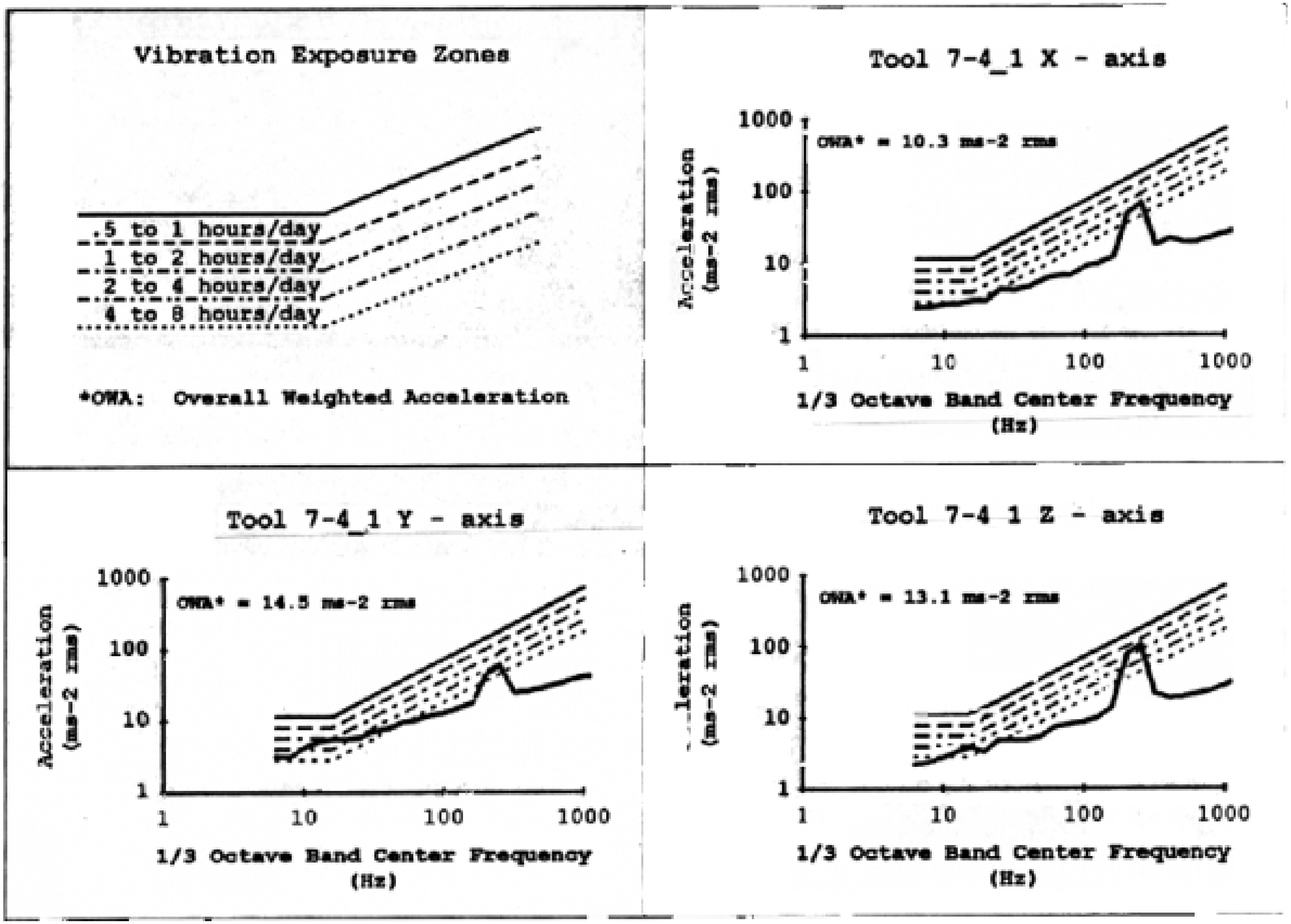

Figure 12: Frequency Spectra of Tool Acceleration Levels for Tool 8
HETA 93-510
Ross Mould
Washington, Pennsylvania

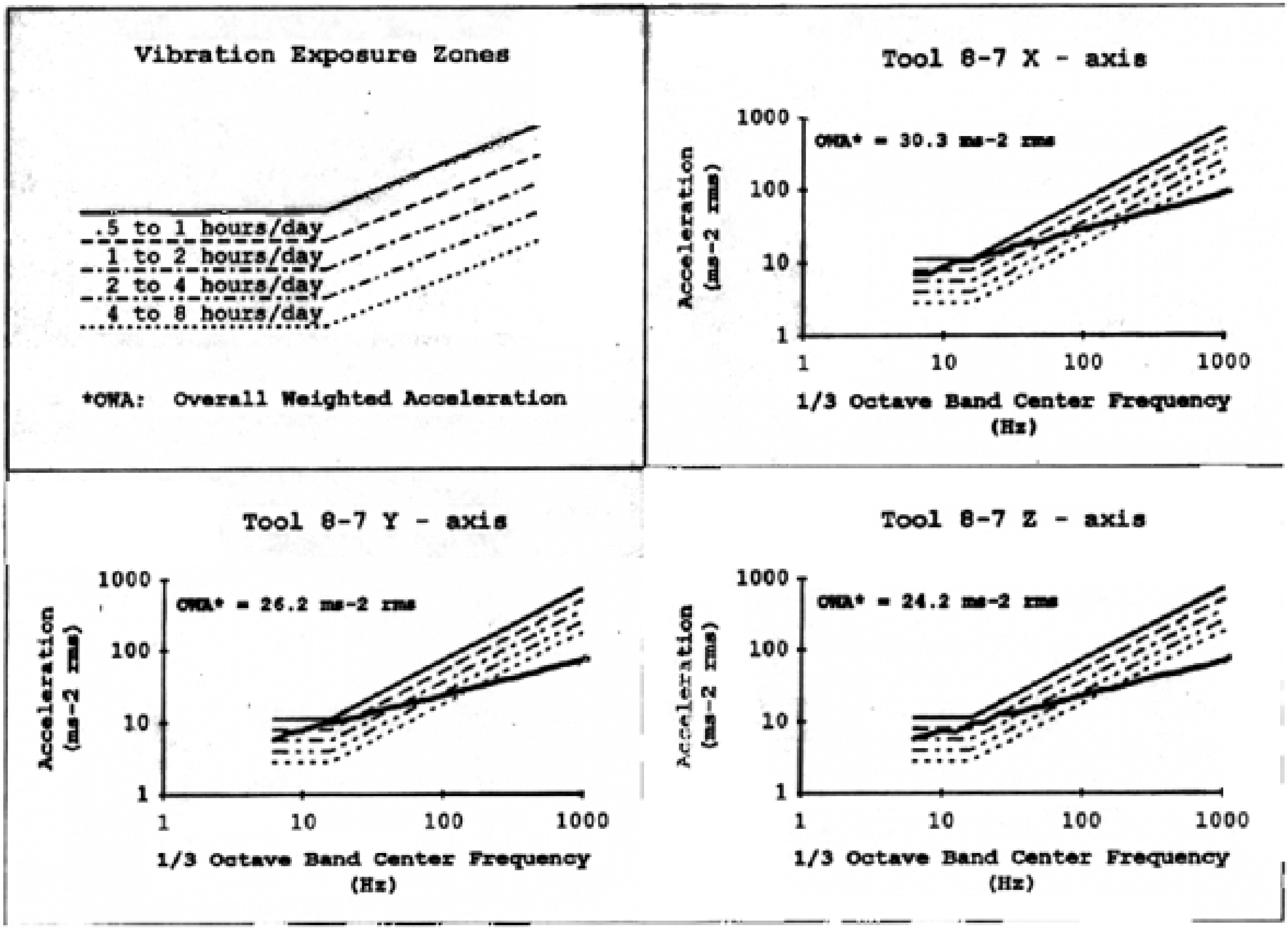

Figure 13: Frequency Spectra of Tool Acceleration Levels for Tool 9
HETA 93-510
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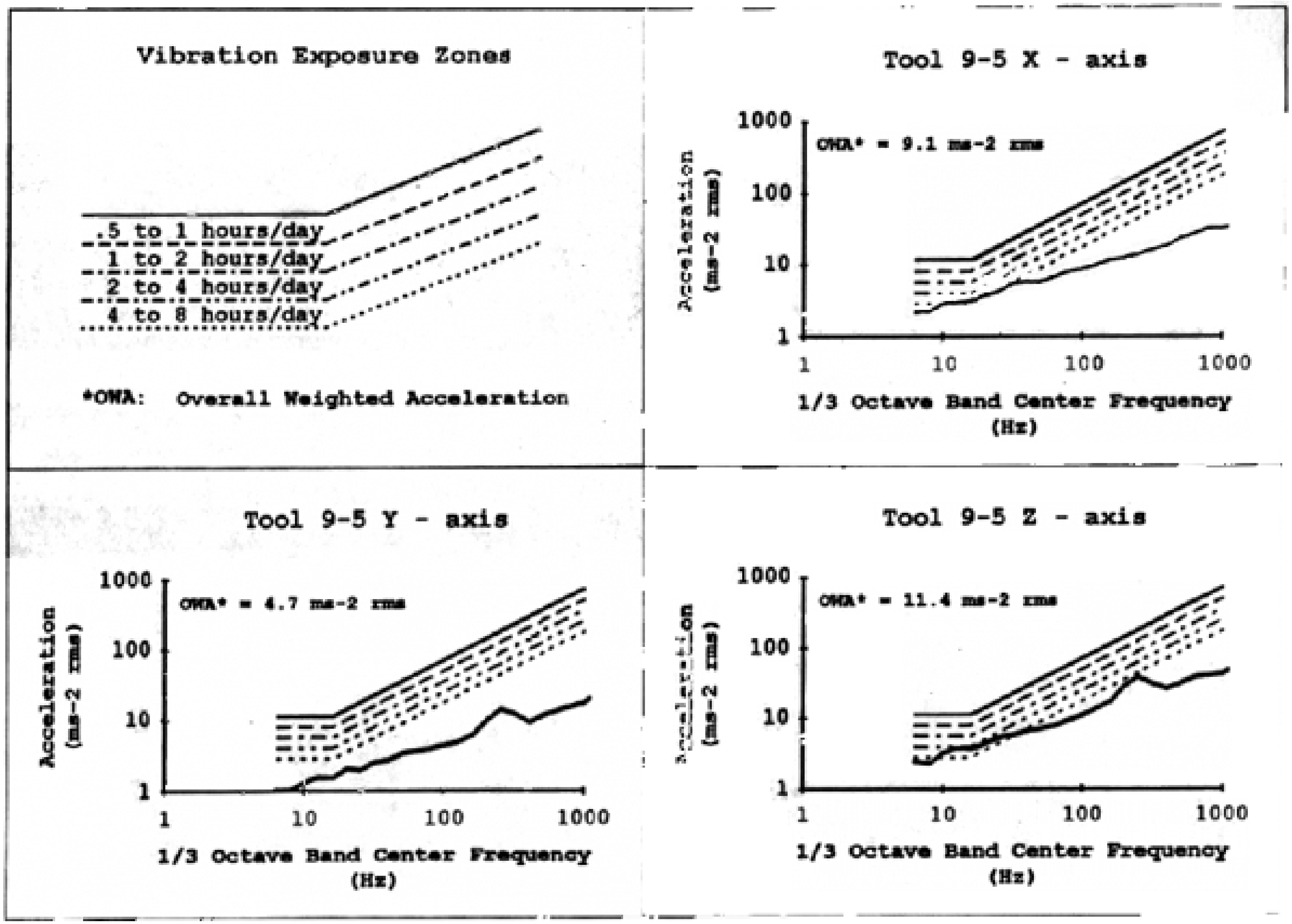

Figure 14: Frequency Spectra of Tool Acceleration Levels for Tool 10
HETA 93-510
Ross Mould
Washington, Pennsylvania

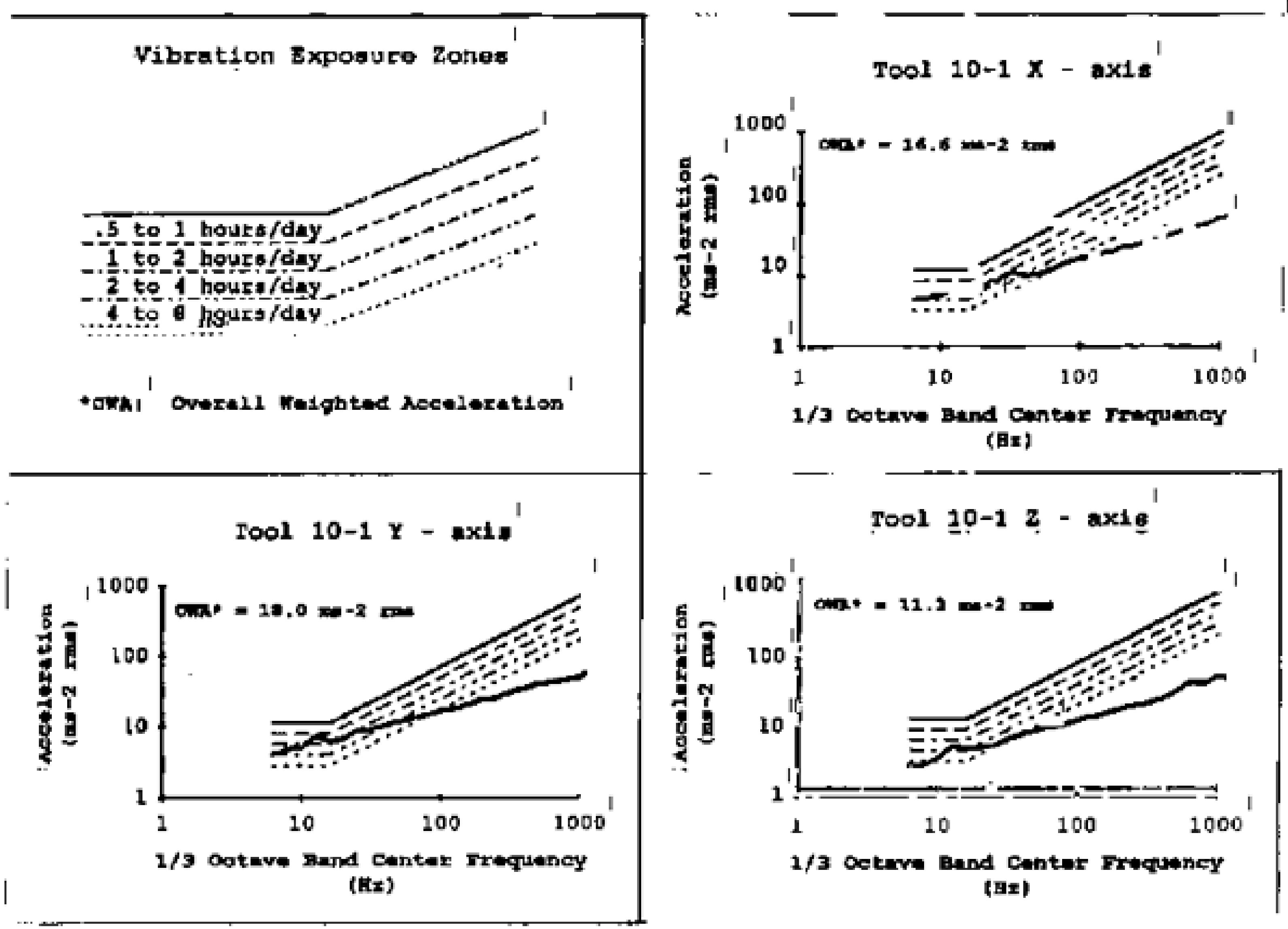

Figure 15: Frequency Spectra of Tool Acceleration Levels for Tool 11
HETA 93-510
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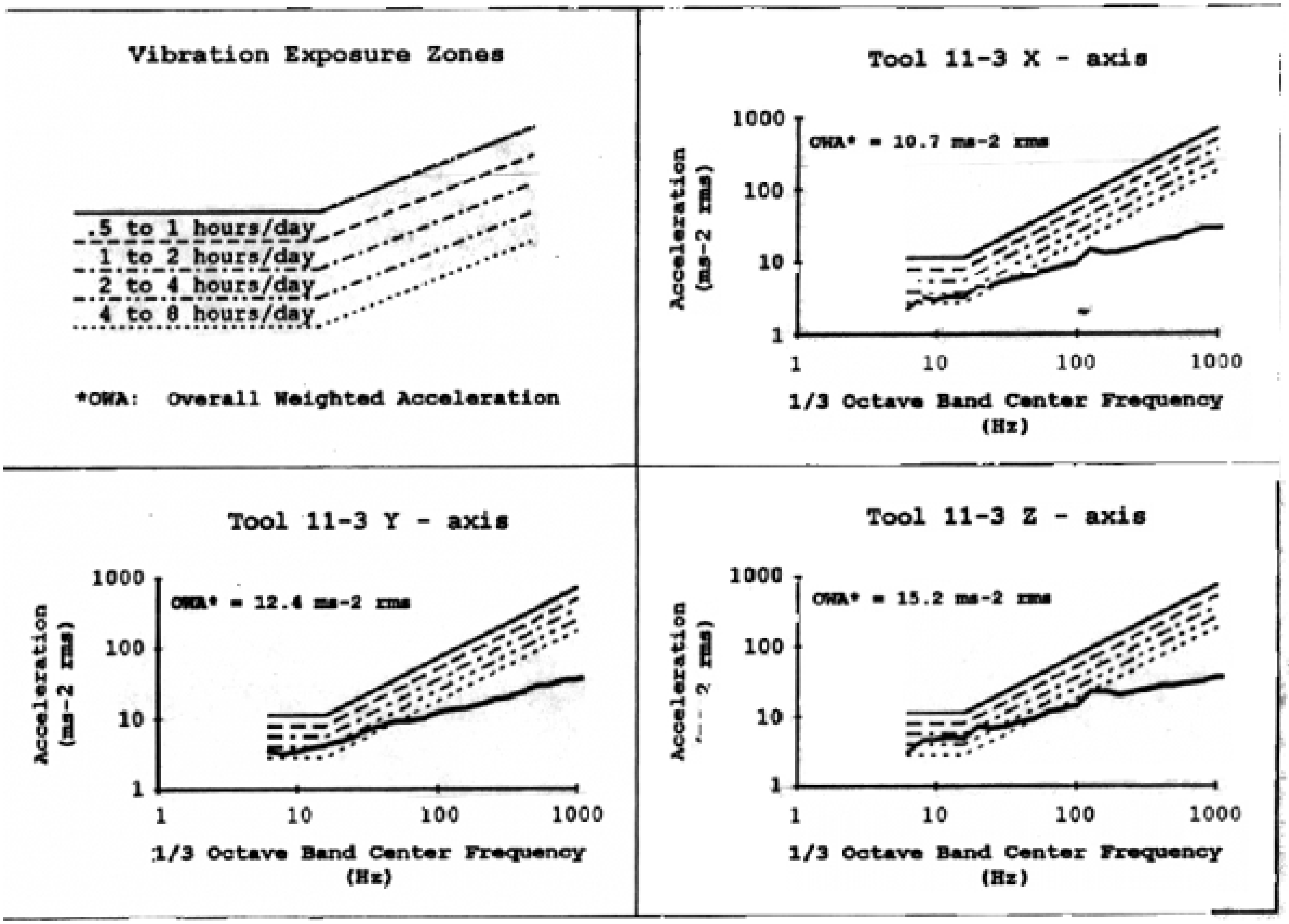

Figure 16: Frequency Spectra of Tool Acceleration Levels for Tool 12
HETA 93-510
Ross Mould
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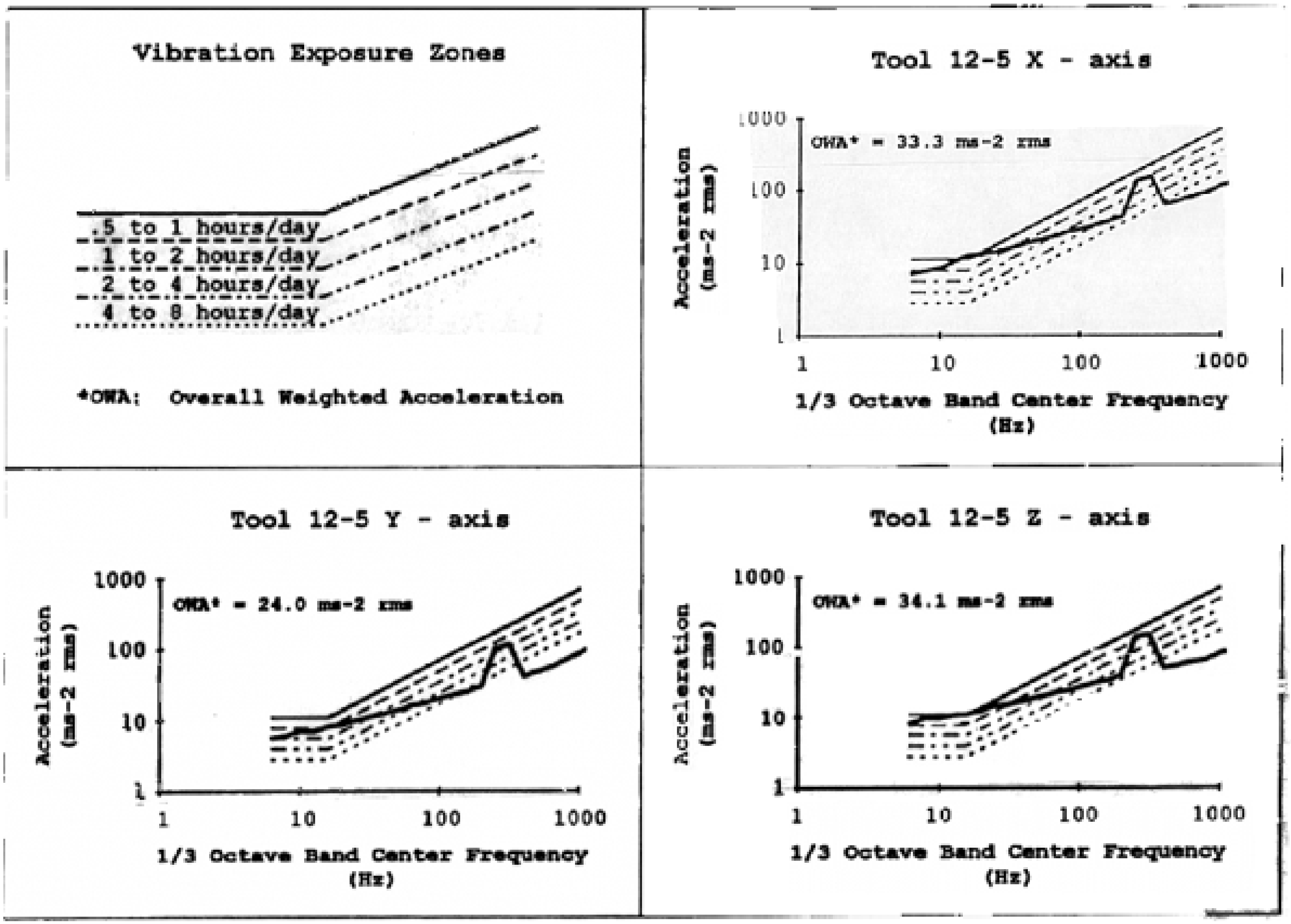

Figure 17: Frequency Spectra of Tool Acceleration Levels for Tool 13
HETA 93-510
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Washington, Pennsylvania

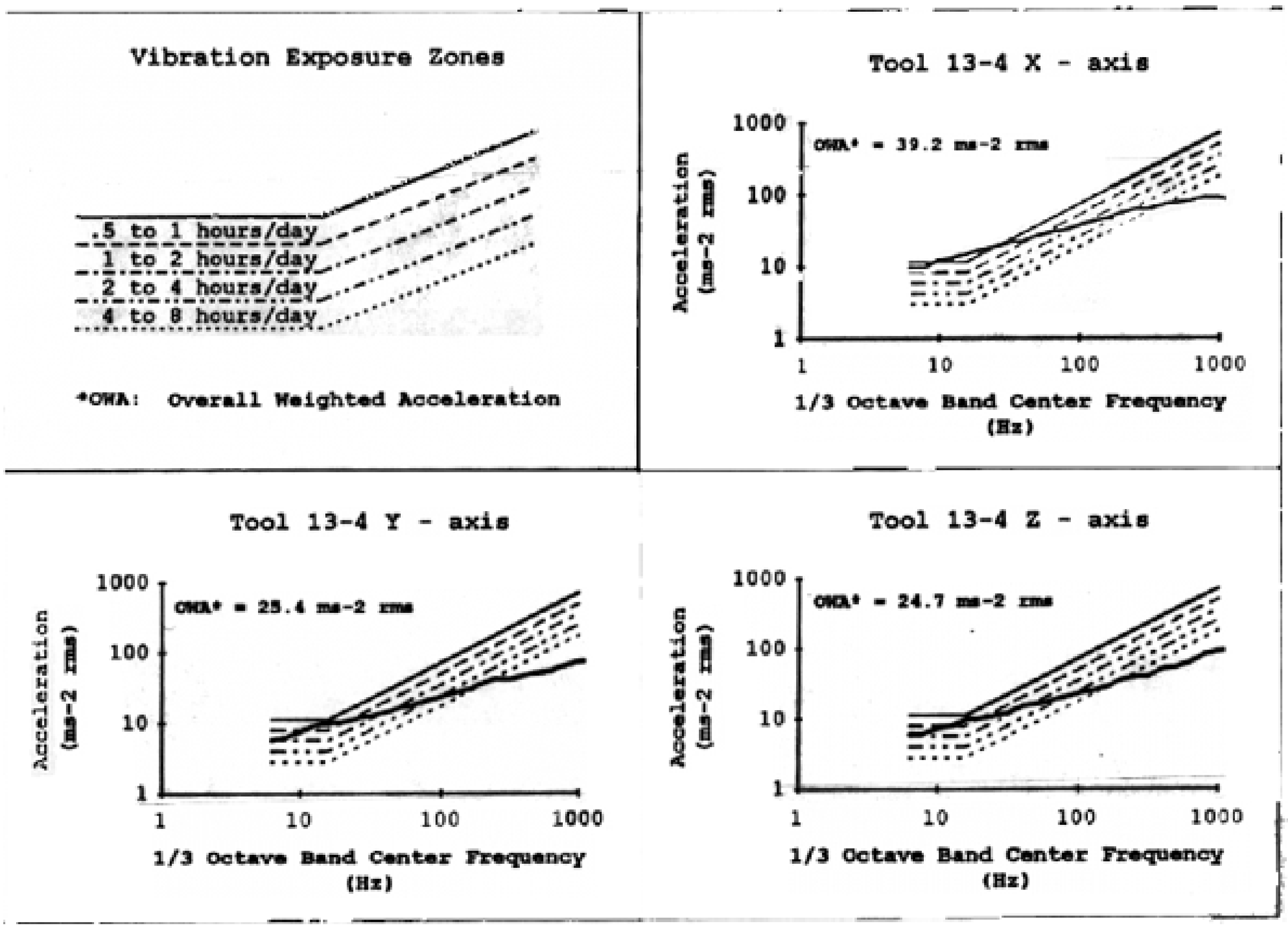


Figure 18: Frequency Spectra of Tool Acceleration Levels for Tool 14
HETA 93-510
Ross Mould
Washington, Pennsylvania

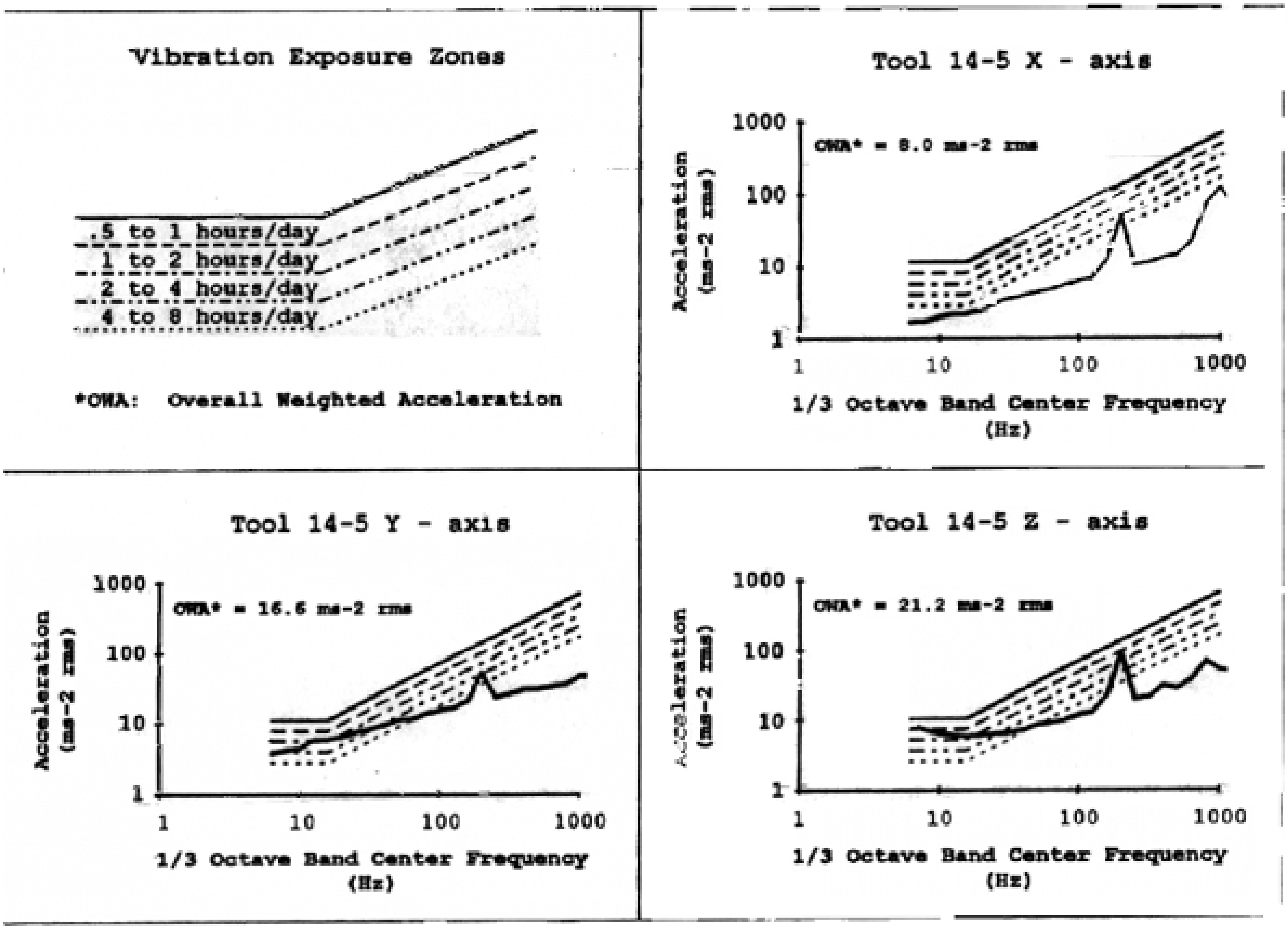


Figure 19: Frequency Spectra of Tool Acceleration Levels for Tool 15
HETA 93-510
Ross Mould
Washington, Pennsylvania

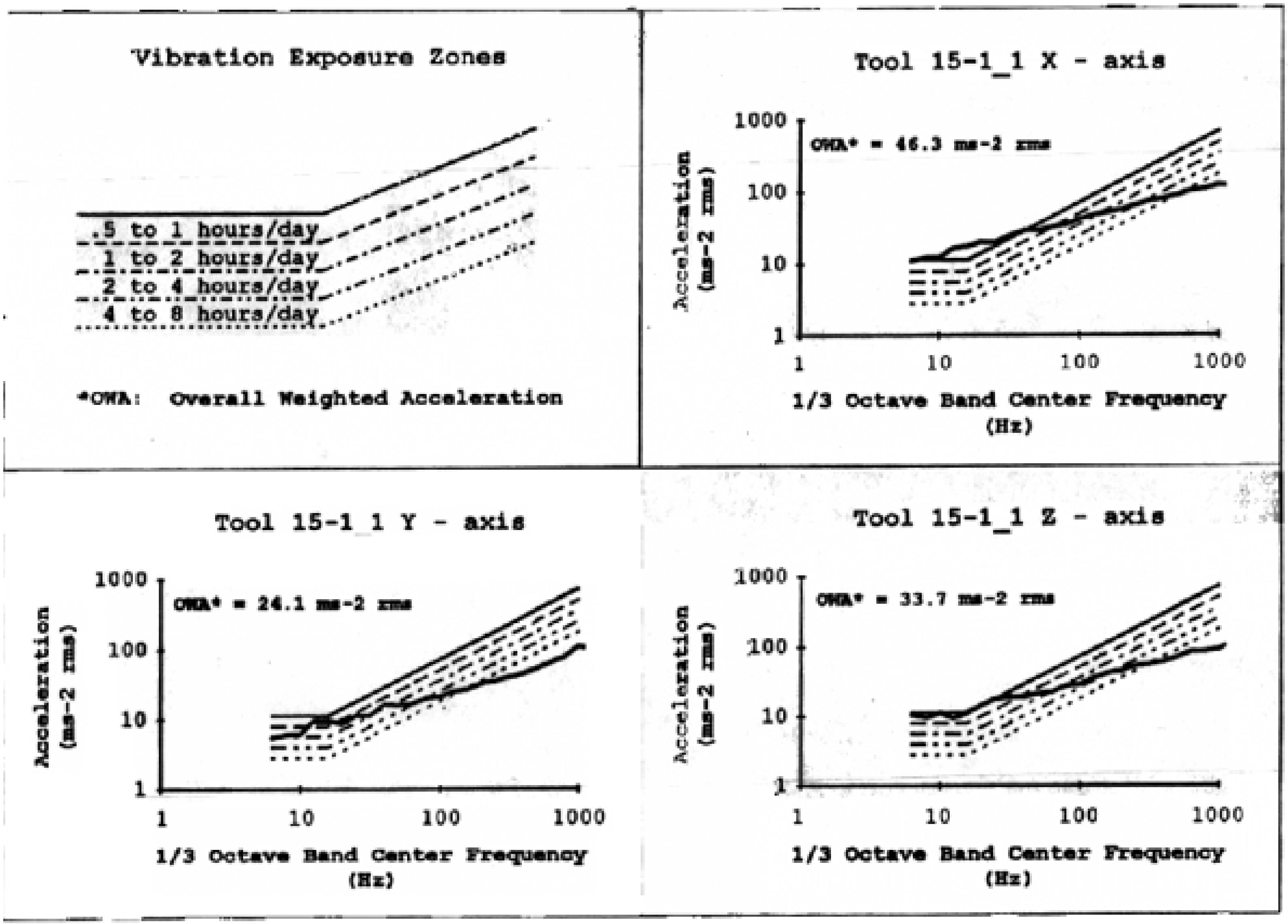


Figure 20: Frequency Spectra of Tool Acceleration Levels for Tool 16
HETA 93-510
Ross Mould
Washington, Pennsylvania

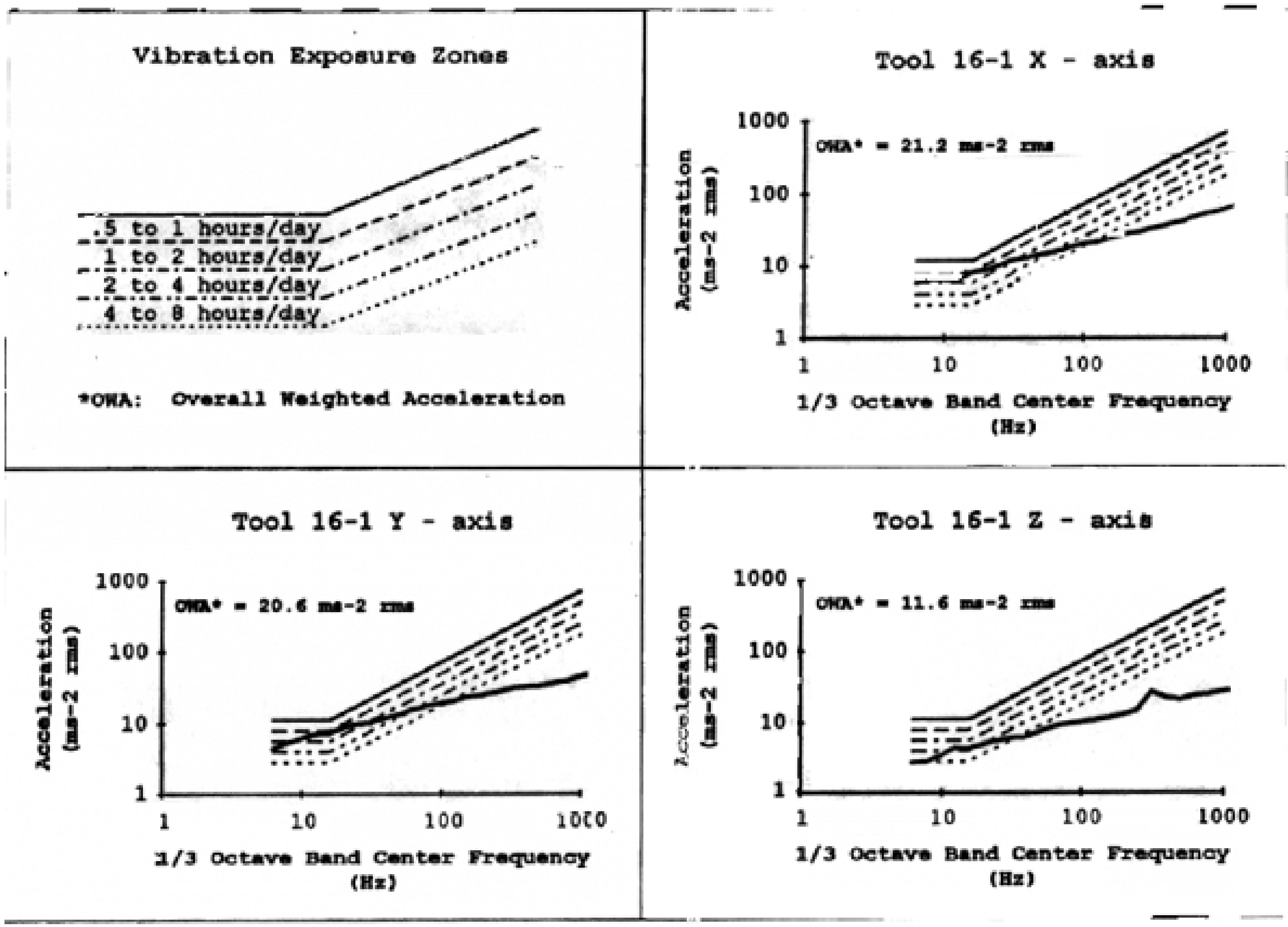


Figure 21: Frequency Spectra of Tool Acceleration Levels for Tool 17
HETA 93-510
Ross Mould
Washington, Pennsylvania

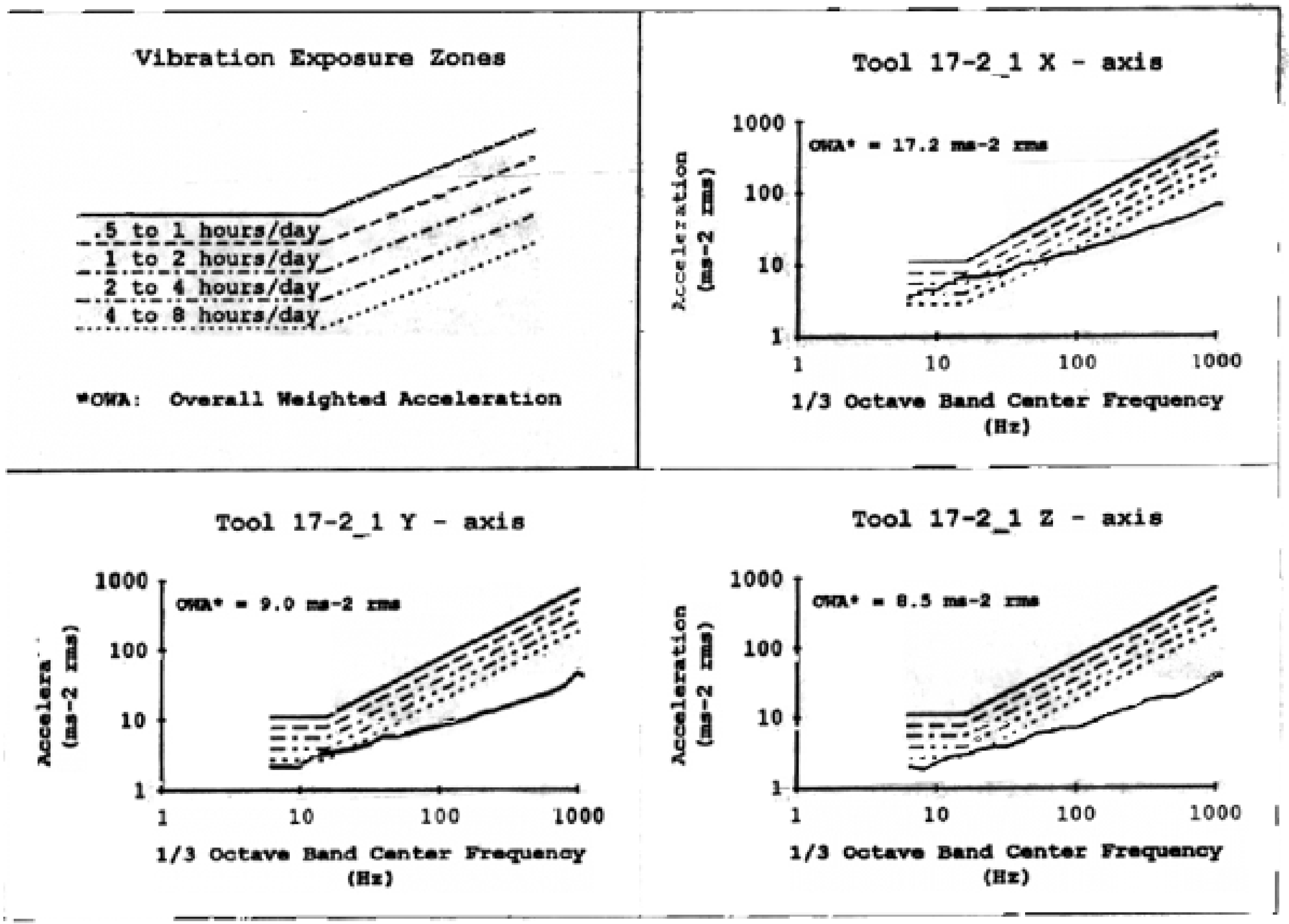


Figure 22: Frequency Spectra of Tool Acceleration Levels for Tool 18
HETA 93-510
Ross Mould
Washington, Pennsylvania

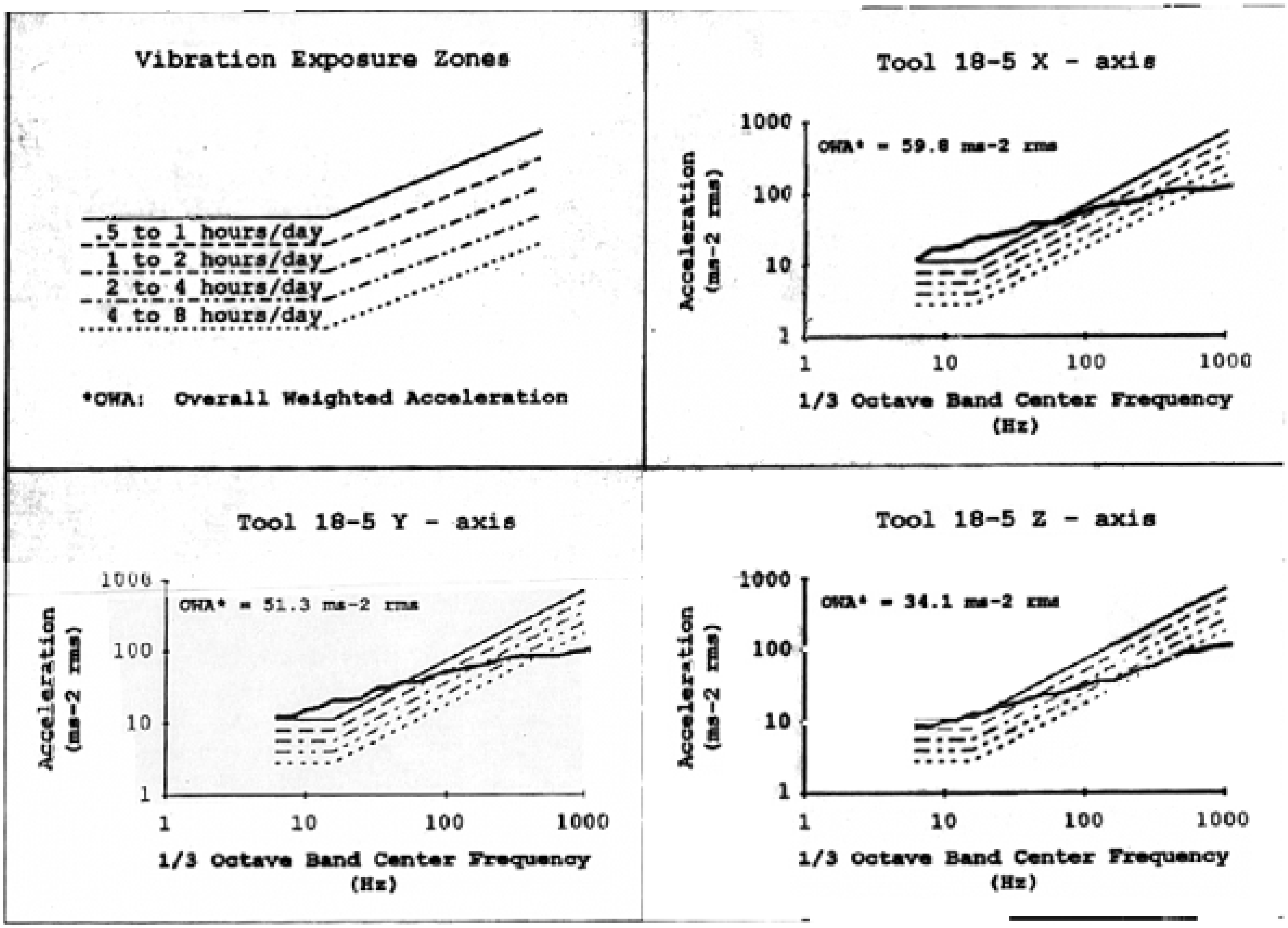


Figure 23: Frequency Spectra of Tool Acceleration Levels for Tool 19
HETA 93-510
Ross Mould
Washington, Pennsylvania

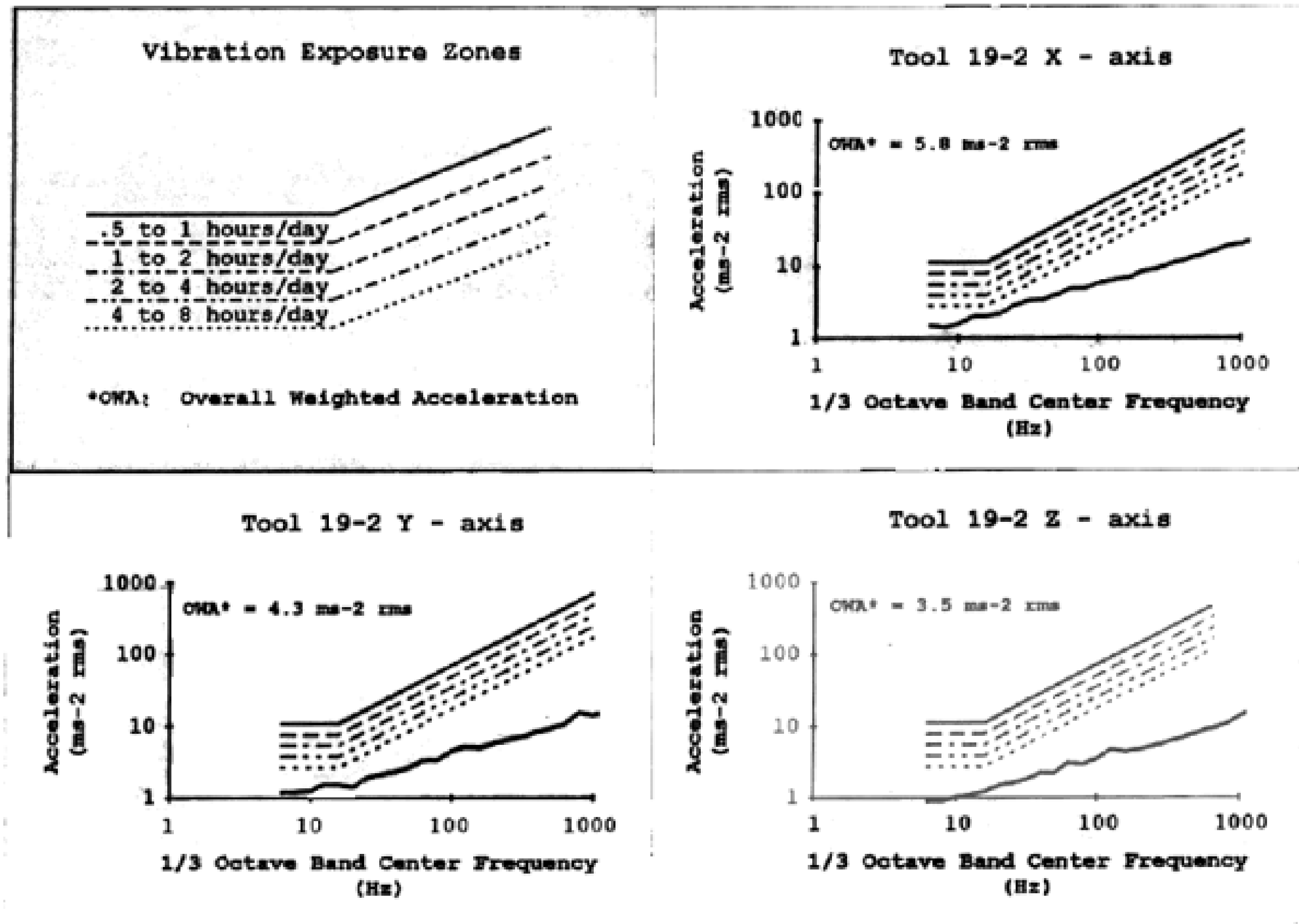


Figure 24: Frequency Spectra of Tool Acceleration Levels for Tool 20
HETA 93-510
Ross Mould
Washington, Pennsylvania

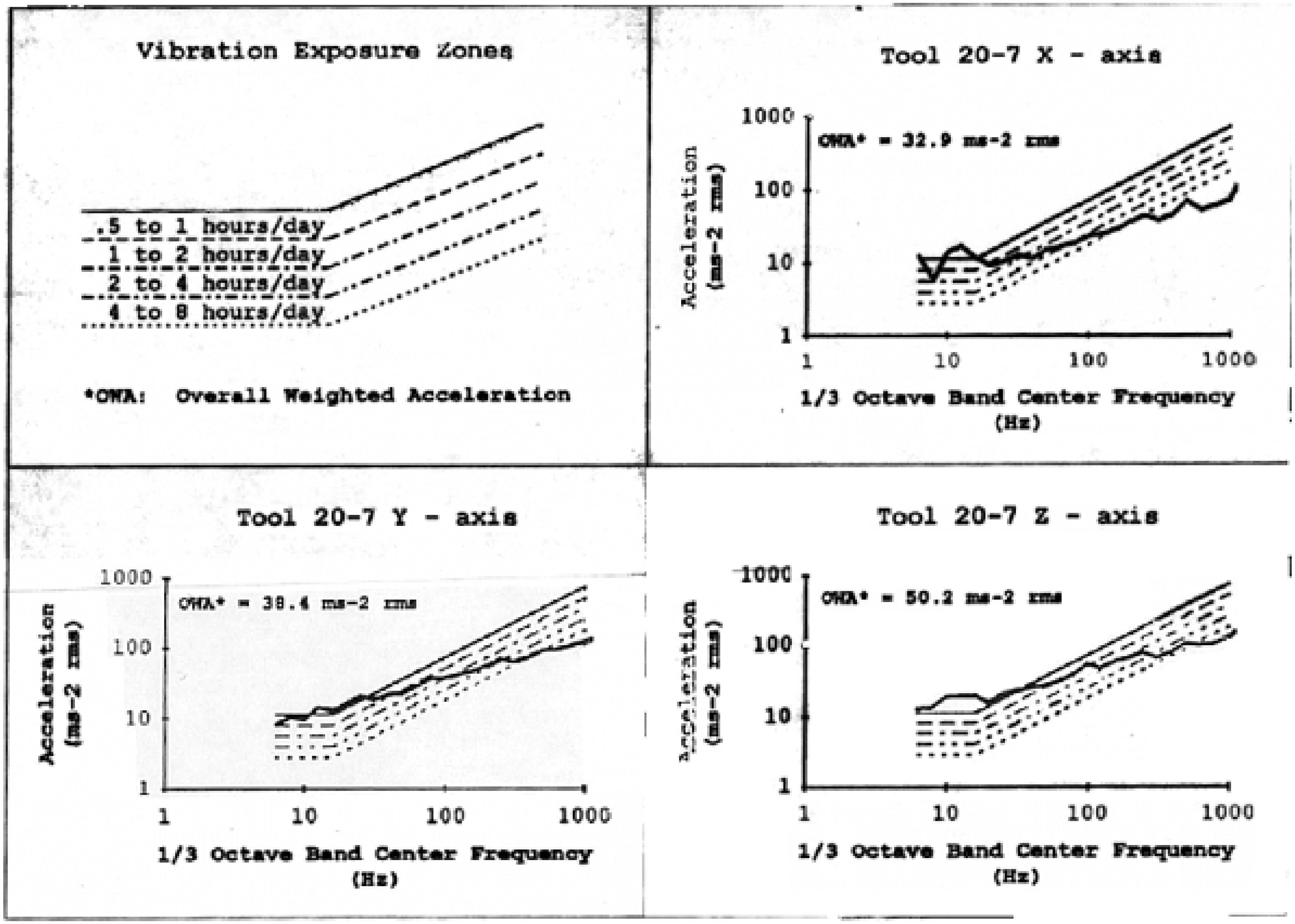
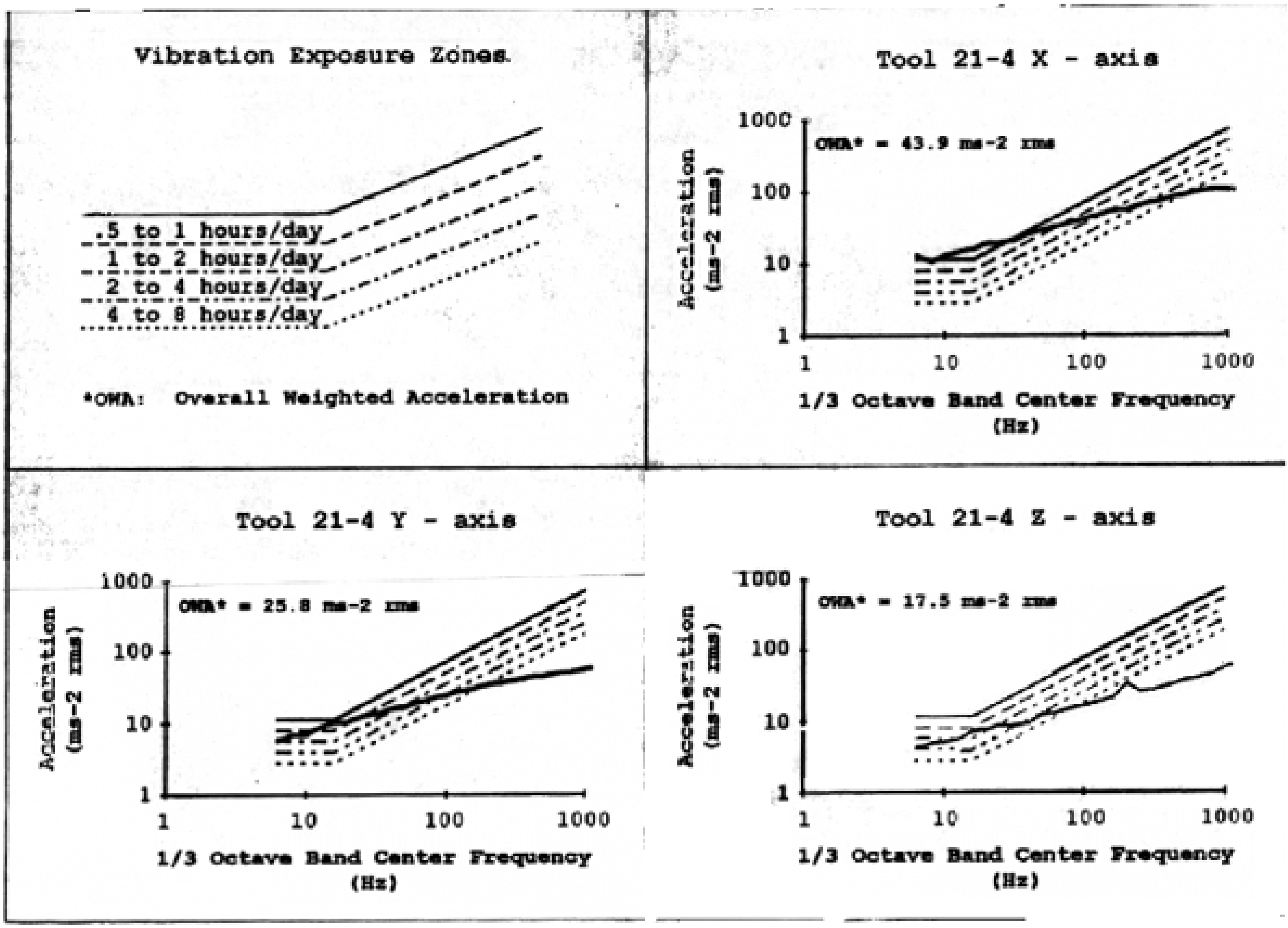


Figure 25: Frequency Spectra of Tool Acceleration Levels for Tool 21
HETA 93-510
Ross Mould
Washington, Pennsylvania



Attachment 1: Ten Items of a Respiratory Protection Program
HETA 93-0562
Ohio University
Athens, Ohio

The Occupational Safety and Health Administration's General Industrial Standard on respiratory protection, 29 CFR 1910.134, which also applies to construction industry, requires that a respiratory protection program be established by the employer and that appropriate respirators be provided and be effective when such equipment is necessary to protect the health of the employee. They should be used as a primary control for employee protection only where engineering controls are not feasible or are currently being installed. The standard requires the employer to address ten basic requirements which would provide for an acceptable respiratory protection program. These requirements are summarized below for easy reference:

I. Provide Written Operating Procedures

The employer must prepare written standard operating procedures governing the selection and use of respirators. The procedures must include a discussion or explanation of all items specified in 29 CFR 1910.134(b).

II. Proper Selection of Respirator

The proper selection of a suitable respirator is dependant upon a number of parameters including: physical nature of the contaminant, concentration of contaminant in the air, toxicity of contaminant and warning properties of the substance (e.g., odor or irritation, which can indicate the end of the service life of the respirator).

III. Training and Fitting for the Employee

Requires that the user be instructed and trained in the proper use of respirators and their limitations, as well as with their maintenance. Qualitative fit testing of respirators fit in a test atmosphere is required. Some OSHA standards now require quantitative fit testing before assignment of a respirator to any employee. In addition, the employee shall be familiar with personal face fit testing techniques and perform this practice of fitting each time the respirator is worn.

IV. Cleaning and Disinfecting

Respirators should be cleaned and disinfected on a daily basis if used routinely throughout the day or less frequently if used less often. Respirator cleanliness is particularly important in dusty environments or where respirators are shared by several individuals.

V. Storage

Respirators should be stored in a dry, clean storage area which is protected from extremes in temperature, sunlight or physical damage.

VI. Inspection and Maintenance

Inspection schedules vary in frequency for specific types of respiratory protection equipment but should at least be inspected for damage or malfunctions both before and after each daily use. Records must be kept for emergency use respirators of at least monthly inspection dates and the inspectors findings. Developing a check list of items to look for is a good idea when inspecting any reusable respirator.

VII. Work Area Surveillance

Surveillance by the employer of the work area is required and includes identification of the contaminant, nature of the hazard, concentration at the breathing zone, and if appropriate, biological monitoring.

VIII. Inspection and Evaluation of Program

The effectiveness of the instituted program measures should be periodically evaluated. It is the employer's responsibility to administer the respiratory protection program so that it is effective. This includes mandatory employee participation where appropriate and provision of all other items cited herein.

IX. Medical Examination

It is required that a medical assessment of the employees ability to wear a respirator be performed prior to providing him with a respirator.

X. Approved Respirators

Only respiratory protection devices approved by NIOSH or MSHA, or both, can be used. Interchanging parts of different respirators nullifies approval.

Further information on respirators and instructions for establishing an appropriate respiratory protection program can be found in the NIOSH guide to Industrial Respiratory Protection, DHHS (NIOSH) Publication No. 87-116. Single copies are available free and can be obtained from:

Publications Dissemination, DSDTT
National Institute for Occupational Safety and Health
4676 Columbia Parkway
Cincinnati, Ohio 45226
(513) 841-4287

Attachment 2: Components of a medical monitoring program for HAV exposures (taken from NIOSH Criteria for a recommended standard: Occupational Exposure to Hand-Arm Vibration) HETA 93-510 Ross Mould Washington, Pennsylvania

General

1. The employer shall provide a health monitoring program for all workers occupationally exposed to hand-arm vibration from the use of vibrating tools.

2. The employer shall ensure that all medical examinations and procedures are performed by or under the direction of a licensed physician with special training and experience in occupational health problems. Board certification in occupational medicine is one way to demonstrate such training and experience.

3. The employer or physician shall (a) counsel all workers who use tobacco about its possible role in augmenting the harmful effects of vibrating tools, and (b) encourage these workers to stop using tobacco.

Preplacement Medical Examinations

At a minimum, a preplacement medical examination shall be conducted for each worker who will use vibrating tools on the job. The baseline data obtained from these examinations are for comparison with the data derived from the periodic medical examinations. The examination shall include the following:

1. A comprehensive work history with special emphasis on present or past use of vibrating tools during work or hobby activities

2. A medical history, including relevant information on any peripheral vascular, peripheral neural, or musculoskeletal activities

3. A comprehensive physical examination with special attention to peripheral vascular and peripheral neural integrity, grip strength, muscle force, and signs and symptoms of the disorders listed in Table IV-1

4. An assessment of the use of substances that influence normal vascular and neural function, which include certain prescription drugs, alcohol, tobacco, and illicit substances.

Periodic Medical Examinations

1. Periodic medical examinations shall be made available at least annually to all workers who use vibrating tools on the job. The periodic medical examination shall include all those items specified in Chapter 1, Section 3b, and any other items considered relevant by the examining physician. If circumstances warrant (e.g., an increase in job-related vibration exposure, or a change in health status), the medical examination shall be offered at shorter intervals at the discretion of the attending physician.

2. The peripheral neural and peripheral vascular signs and symptoms noted during the examination shall be reported in conformance with the classification presented in Tables IV-4 and IV-5.

Medical Removal

Any worker occupationally exposed to hand-transmitted vibration who develops peripheral neural or peripheral vascular signs and symptoms of Stage 2 HAVS or above on the Stockholm Workshop classification described in Tables IV-4 and IV-5 shall not be exposed to further hand-arm vibration until his or her signs and symptoms have improved sufficiently that they no longer meet the criteria for Stage 1 HAVS.

If the attending physician recommends that a worker be removed form a job requiring the use of vibrating tools, the employer shall ensure that the worker retains all earnings, seniority, and other employment rights and benefits.

Information for Health Care Professionals

The employer shall furnish the following information to the health care professional responsible for the medical monitoring program:

- A copy of this criteria document
- A description of the worker's duties and activities as they relate to vibration exposure
- An estimate of the worker's daily exposure to vibration and years of exposure
- A list of basic types of vibrating tools used
- A list of the acceleration levels produced by the tools
- A description of antivibration protective clothing and antivibration tool designs in use
- A list of all tasks that involve vibrating tools and workpieces and that require strong hand grip force

- Relevant information from previous work and medical histories and medical examinations

- A description of the special features of the task and the way in which this task is performed

- A description of the environmental conditions at the work site (ambient temperature, humidity, wind velocity, rain, snow, etc.)

Written Report and Opinion

The employer shall receive the following information from the attending health care professional:

- An opinion as to the worker's ability to use vibrating tools

- Any recommended limitations to on-the-job exposure

- Any limitation to the worker's ability to use any required protective equipment or clothing

- With the worker's written consent, information about any condition requiring treatment or special consideration